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Reasons for the low usage of scheduling software and the difference in production performance between users and nonusers of scheduling software from a lean manufacturing perspective

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Reasons for the Low Usage of Scheduling Software and the Difference in Production Performance Between Users and Nonusers of Scheduling Software From a Lean Manufacturing Perspective

by Sandra Yveborg

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Abstract

It is more important than ever for printers to improve efficiency and productivity, and the means for doing so are available. Computer-assisted scheduling is one method that is claimed to increase throughput speed and reduce costs, among other benefits. Recently, scheduling applications have started to increase in popularity, and many management information systems (MISs) have built-in scheduling features. However, only 15% of the companies that own scheduling software utilize it. The first part of this research project seeks to determine the reasons for the low usage.

Another way to increase efficiency is through Lean manufacturing, a strategy for eliminating non-value-added activities, such as defects, excess inventory, and overproduction. Lean manufacturing and computer-assisted scheduling share many of the same objectives. The second part of the research project seeks to determine whether or not there is a difference in production performance between users and nonusers of scheduling software from a lean manufacturing perspective.

The analysis is based on data collected through an email questionnaire from 60 commercial printing companies in the U.S. It was found that the surveyed companies who own scheduling software but do not use it, do not rely on the application’s capability because they believe that they can achieve better control with manual scheduling. Furthermore, they believe scheduling software is difficult to integrate with their workflow. Companies who have owned an MIS for 5 years or fewer have a more

negative perception about scheduling software compared with those who have owned one for a longer time.

In the research, it was also found that companies using scheduling software have higher utilization rates of equipment, shorter lead times for paper storage, and a higher percentage of short makereadies out of the total number of makreadies. Nonusers of scheduling software have shorter throughput time and shorter waiting time for a job between preflighting and platemaking, between platemaking and plate mounting, and between completed printing and the first postpress operation. In general, the scheduling software users in the study are more homogeneous as a group in performance, whereas the nonusers are more diverse in performance, with a relatively high percentage performing at a very low or very high level.

The implication of the study is that scheduling software needs to be more user-friendly and easier to customize to increase the flexibility and capability of integrating it into a workflow. Furthermore, companies that own scheduling software, but do not use it, should investigate the possibility of achieving better performance by beginning to use the scheduling application. Scheduling software that is already in house has the capability of enhancing a lean manufacturing effort.

Chapter 1

Introduction

Topic Statement

This research project seeks to determine the reasons why many printing companies refuse to use the scheduling module/software they already own. Furthermore, a set of performance parameters and waste categories, defined from a lean manufacturing perspective, are investigated in an attempt to determine whether or not there is a difference between users and nonusers of scheduling software. Hence, the research may indicate an opportunity to enhance a lean manufacturing effort with scheduling software.

Significance of the Topic

Representatives from two print media organizations have expressed interest in determining reasons for the low usage of scheduling software among companies that already own such software. The findings should also be a source of inspiration for vendors of management information system (MIS) in their future development of scheduling applications to better suit printers' needs.

In a context of efforts to gain efficiency and productivity, literature delves deeply into discussions about achievements either through technology (computer integrated manufacturing [CIM] and MIS) or through quality strategies (Six Sigma, lean manufacturing). Very few sources ever make a connection between the two. Therefore, this research project also aims to draw attention to the potential benefits of combining technology (scheduling software) and philosophical (lean manufacturing) strategies to gain efficiency and productivity.

Reasons for Interest

The researcher has a personal interest in the different methodologies for improving printers' efficiency, productivity, and profitability and wishes to work within this area in the future. This research represents an exclusive opportunity for the researcher to become familiar with lean manufacturing and efficiency-gaining technology. The area is of particular interest because it includes work with both technological and human resources, and the topic is of significance for individuals running a business. Both lean manufacturing and computer-assisted scheduling are topics that will very likely become increasingly important in the future.

Glossary of Acronyms and Abbreviations

The following list presents frequently used acronyms and abbreviations.

CIM – Computer Integrated Manufacturing
The integration of a total manufacturing enterprise so that data can be shared across departments (Kraebber & Rehg, 2005).

CIP3 – International Cooperation for Integration of Prepress, Press and Postpress
An organization, founded in 1995, that established standards for automation of ink key settings and bindery operations. CIP3 was an important initiative toward CIM for the printing industry (CIP4, 2007).

CIP4 – International Cooperation for the Integration of Processes in Prepress, Press and Postpress
In 2000, CIP3 was reformed and became CIP4. CIP4 is an organization that establishes standards for data transfer for the printing industry (CIP4, 2007).

ERP – Enterprise Resource Planning systems
Integrated enterprise-wide information systems that coordinate key internal processes of the firm (Laudon & Laudon, 2007).

JDF – Job Definition Format
A proposed standard for the graphic arts and printing industry to facilitate information and data transfer between disparate systems and platforms. Developed by CIP4 (Gehman, 2003).

JIT – Just-in-Time
A philosophy (and one of the pillars of lean manufacturing) in which materials and processes are delivered right at the time they are needed to reduce inventory (Allen, 2001a)

JMF – Job Messaging Format
An integrated function of JDF that controls and commands devices on the shop floor. For example, it tells a device when to start and stop (CIP4, 2007).

MIS – Management Information System
In the graphic arts industry, the term MIS is used to describe a print-specific ERP system (Gehman, 2003; PrintCom & Mason, 2005). It is an application in which all production activity is reported and from where the business can be managed and controlled (Mauro, 2007). In a nonprinting environment, the term MIS typically refers to financial reporting applications supporting middle management (Laudon & Laudon, 2007).

TPM – Total Productive Maintenance
A lean manufacturing activity for standardizing maintenance and making it a built-in duty in every employee's daily routines (Cooper, Keif, & Macro, 2007; Robinson, 2001).

WIP – Work in Progress
Any material in the process between raw material and finished product (Meier, 2001a)

XML – Extensible Markup Language
A nonproprietary and extremely flexible programming meta-language used to describe other languages (CIP4, 2007; Gehman, 2003).

Chapter 2

Review of Literature

The following five areas are covered in the literature review: overview of the U.S. printing industry, computer integrated manufacturing, management information systems, scheduling, and lean manufacturing. Chapter 2 ends with a summary and conclusions based on the information in the literature review.

Overview of the Printing Industry

The U.S. printing industry is comprised of some 35,000 printing plants. Based on the number of establishments, sales volume, and number of employees, it is one of the largest industries in the U.S. and one of the top ten in the world. The total sales volume for the U.S. printing industry reached $150 billion in 2004 (PrintCom & Mason, 2005). In 2006, the sales volume for the commercial printing industry was $87.3 billion, which was a 5.4% increase from the previous year (Paparozzi, 2007). A commercial printer is any company that provides commercial printing services – whether generalist or specialist and regardless of process. Excluded are: in-plants, trade shops, publishers, converters, copy shops, and companies that are primarily business forms printers and quick printers (email conversation with Paparozzi, 2008).

The major part of the industry is comprised of small, privately owned companies with fewer than 20 employees, and the diversity in terms of type and age of equipment, software, operating practices, and management sophistication is broad (PrintCom & Mason, 2005).

The sales volume has grown since 2003, but competition in the market is very intense (Paparozzi, 2007), and the number of consolidations has increased over the last decade (PrintCom & Mason, 2005). Since 1998, nearly 6,500 establishments have ceased to exist, which represent a reduction of 17.1% (Paparozzi, 2007). The printing industry's complexity is larger than ever, with demands for tougher jobs in shorter runs, faster turnaround times, and more colors, and with the need to run more jobs to maintain the same profitability (Gehman, 2003). Ruggles (1996) reports on the shortening of cycle times; in the early 1980s, the lead time to produce a printed product was about 20 days, compared to 5 days or fewer in the mid 1990s. Competition for jobs has changed due to globalization and the Internet. Now the competition is not only between printers in the same city, but also between printers across the country and worldwide, and against the electronic alternatives to print (Paparozzi, 2007). The tough competition between printers regarding price pressure will continue to be intense over the coming year (Davis, 2007), and an increase in costs is to be expected. The major cost pressure is expected to come from increased paper costs, rising energy prices, increased health care costs, and rising wages and salaries (Davis & Gleeson, 2007).

Customers expect a greater service mix far beyond ink-on-paper, such as efficient workflows that reach right into their facilities via the Internet. Given the new service demand, integration is essential to contribute to clients' success (Paparozzi, 2007).

Integration, communication, and automation are frequently used words in almost any article regarding printing companies' future survival (Gehman, 2003). As the profit from each print job has decreased, and continues to decrease, the need to monitor the costs related to each job increases. In particular, the costs of the administrative processes and selling activity related to the jobs are poorly monitored today (Vision in Print, 2006).

In a Trade Association for Excellence in Graphic Communications Management (NAPL) 2007 State of the Industry Survey, completed by nearly 350 printing companies, it was revealed that printers see automation as one of the most important changes for improving long-term profitability. Also, due to the intense and diverse competition, the participants agree that efficiency and productivity have never been more important. Participants want to invest in new equipment, hardware, and software to minimize labor costs; develop a seamless digital workflow; reduce bottlenecks and inefficiencies; and minimize waste, spoilage, and rework. They also expressed interest in continuously improving and "embracing advanced, scientific manufacturing methods" (Paparozzi, 2007, p. 8). Paparozzi reports that lack of time, uncertainty in where to invest, an uncertain future, the economy, and the market are factors that make printers wait to invest in equipment, hardware, and software. However, because of the ongoing structural changes within the industry, the risk of doing nothing cannot be ignored.

The suggestions among the consultants for maintaining future profitability are many: Prince (2007) suggests improved productivity, and Goldman (2006b) claims that streamlined operations and improved plant-wide communications are important areas to invest in. Furthermore, he says that the future investments are not dependent on technologies, but rather on “investments and commitments to using tools that will change the way to do business” (p. 38).

Computer Integrated Manufacturing

Computer integrated manufacturing (CIM) is a way for manufacturing companies to manage the new technologies more efficiently so that benefits such as increased profitability and improved market share can be reached (Kraebber & Rehg, 2005). CIM is becoming important for the printing industry as it moves from traditional craftsmanship toward industrial production and modern manufacturing (Gehman, 2003; Kipphan, 2001).

The phrase “computer integrated manufacturing” was first coined in 1973 by Joseph Harrington, Jr. (Kraebber & Rehg, 2005). However, computerization and automation of manufacturing operations began many years before the phrase was introduced (Bann, 2007; PrintCom & Mason, 2005).

The Computer and Automation Systems Association (CASA) of the Society of Manufacturing Engineers (SME) has a strict definition of CIM:

> CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personnel efficiency (Kraebber & Rehg, 2005, p. 24).

Kraebber and Rehg (2005) emphasize that CIM is more than just hardware or a manufacturing system installed by a vendor, or any kind of software or manufacturing strategy. An important piece of a successful implementation of CIM is the managerial philosophy that bases decisions on customer satisfaction, values employees' ideas, and works toward continuous improvement and a total quality mentality.

In the printing industry, the term CIM is not used with consistency and does not always seem to correspond with CASA/SME's definition. Kipphan (2001) describes the purpose of CIM as a "development to achieve a networked print-house" (p. 928). PrintCom and Mason (2005) use the term CIM interchangeably with "computer integrated automation," and define it as: "computers interacting with electronic devices on a real-time basis to control the entire production process" (p. ii). The definition includes the integration of administrative workflow, such as job planning, production estimating, and dynamic scheduling.

The term "Digital Smart Factory" is used to describe printing companies with highly developed IT systems seamlessly connected to each other across the entire enterprise, including customer interfaces, CIM, computerized business systems, and suppliers and third-parties (Gehman, 2003).

Digitization of the Printing Industry and Movement Toward CIM

Electronic and automated equipment started to appear on the printing market in the mid 20th century. In the 1960s, the electronic color scanner was developed (Bann, 2007) and computer-based management systems for performing accounting functions, managing materials, and collecting data appeared on the market (PrintCom & Mason, 2005). Until the 1970s, the prepress workflow was mainly based on analog data (Kipphan, 2001). Desktop publishing was introduced as the first personal computers (PCs) and Apple

Macintosh computers entered the market in the 1980s (Bann, 2007). With the computers also came new software applications that allowed for the development of computer-to-plate (CtP) (Kipphan, 2001). The first lithographic CtP system was launched in 1986 (Smyth, 2005).

In the late 1980s, the printing industry adopted software for managing the estimating and costing functions (Smyth, 2005). During the 1990s, improved specialized software was developed for managing a printing business, allowing affordable applications, even for smaller companies (PrintCom & Mason, 2005). PrintCom and Mason claim that the progress toward CIM began in the mid 1990s with different levels of integration of systems and equipment. The CIP3 organization, founded in 1995, established standards for automation of ink key settings and bindery operations by transferring production-relevant data from prepress to the next step (CIP4, 2007). The CIP3 initiative was an important step for the printing industry's progress toward CIM (Kipphan, 2001). In 2000, CIP3 was reformed and became CIP4. The new organization developed JDF, based on XML, to standardize data transfer and facilitate CIM in the printing industry (CIP4, 2007).

Objectives and Benefits of CIM

The objectives of CIM are to share data across departments and to integrate the enterprise with automation software and hardware. An essential aspect is that production data are entered only once into a common database and can then be used as much as required without the need for any retyping of the data (Kraebber & Rehg, 2005).

The major benefit seen in the printing industry is the time saved, in terms of faster makereadies and minimized retyping of data. Shorter makeready time has a positive influence on waste. Printing and finishing have seen reduced number of waste sheets with CIM. The fact that data is entered only one time reduces the risk of inaccuracy, which improves the quality as well as the accuracy of reproduction and repeatability (Kipphan, 2001; Kraebber & Rehg, 2005). Gehman (2003) adds improved communication, increased customer satisfaction, inventory reduction, improved productivity, Web interface, and more accurate billing to the list of benefits gained from CIM in the printing industry. However, PrintCom and Mason (2005) state that many of the benefits are difficult to "quantify and to justify financially" (p. 194) because the systems work quietly in the background.

Constraints for CIM

The basic criteria for equipment to be integrated into an automation workflow and be controlled by electronic data are that the equipment have digital controls and be motorized (i.e., there is no need for manual settings). Automation in today's printing companies is mainly divided into three isolated spheres – prepress, platemaking, and press – with no exchange of data between them (PrintCom & Mason, 2005).

The prepress department has experienced the largest influence from automated and computerized equipment, but the pressroom has also seen changes. In the bindery, automation is still in its infancy (Kipphan, 2001). Gehman (2003) claims that today automation is the norm rather than the exception. This statement does not agree with

PrintCom and Mason's (2005) findings. They claim that less than 10% of the four-color lithographic printing plants that use CtP have linked prepress with platemaking into integrated automation, and very few companies have gone beyond this step.

In the use of CIM, the printing industry seems to be far behind other manufacturing industries. Between 60% and 75% of the printing presses and up to 80% of the bindery equipment in the commercial segment lack the ability to be integrated into an automated workflow. Legacy equipment is a major constraint for CIM. Furthermore, surveys show that printers lack the interest, have a limited knowledge, and are skeptic about the benefits of CIM. There is also a lack of appropriate IT skills, required to integrate automated systems. Another constraint is the weak financial results. The return on investment (ROI) is difficult to calculate for integrated automation, which might create a resistance to invest. It is also claimed that the job characteristics such as the wide variety of customers and their requirements in terms of substrate, form, and production files, seems to hinder sheetfed printers from gaining benefits from integrated automation (PrintCom & Mason, 2005).

JDF – the Link for CIM

Standards are crucial in CIM for data exchange, automation, digitization, and process control. Standards prevent proprietary equipment from binding printers to a specific vendor or causing problems when trying to interface with other systems or equipment (Gehman, 2003; Kipphan, 2001).

Job Definition Format (JDF) is a proposed standard for the graphic arts and printing industry. It is based on the nonproprietary extensible markup language, XML (CIP4, 2007). XML is a meta-language, which means it is used to describe other languages. This makes it extremely flexible compared to HTML, which "describes how information should look" (Gehman, 2003, p. 21).

The purpose of JDF is to facilitate information and data transfer between disparate systems and platforms – even from different competing manufacturers – and to allow integration into seamless workflows (CIP4, 2007; Gehman, 2003; Goldman, 2006b). Today, much equipment, many prepress systems, and MISs have JDF capabilities (Vision in Print, 2006).

JDF has four main functions (CIP4, 2007):

1) To carry the job specific information from the beginning of a job to its completion. This is usually referred to as an electronic job ticket.
2) To control and command devices on the shop floor. This function is called JMF (Job Messaging Format) and is an integrated part of JDF. It tells a device when to start and stop.
3) To bridge the gap between devices and systems so that workflows and automation can be created.
4) To automatically read the devices' capabilities and carry the information into the management information system. This is called the "handshake."

JDF is not a requirement to link systems into an automated workflow. Other applications can be used and were used long before the development of JDF. Printers may build their own proprietary solutions to work within their organization and for clients (PrintCom & Mason, 2005), or let manufacturers solve the integration issues when installing new equipment (Smyth, 2005). The downside is that new applications can be difficult to integrate and "home-built" proprietary solutions might not be possible to expand fast enough to match organizational growth. Should the developers leave the company, it could be difficult for successors to continue development or to simply adjust for errors (Laudon & Laudon, 2007).

Management Information Systems

Record keeping and use of information is an important part of running and operating a business. Computerized systems for executing those functions are becoming more common as the modern world moves toward digitization (Network PDF, 2007). In other industries, those systems are usually called enterprise resource planning (ERP) systems, manufacturing resource planning (MRP) systems, or back-office applications (Kraebber & Rehg, 2005; Laudon & Laudon, 2007; Network PDF, 2007).

ERP systems, also called enterprise systems, are integrated, enterprise-wide systems that collect data from enterprises' different business and production processes into a single central data repository. These systems facilitate quick access to information, which improves the management decision making process. Examples of functional areas that can be included in the ERP system are finance and accounting, sales and marketing, human resources, and manufacturing and production (Kraebber & Rehg, 2005; Laudon & Laudon, 2007). SAP and Oracle are two of the major developers of ERP systems (Smyth, 2005).

Print-Specific ERP

In the 1960s, print solution companies realized that the generic ERP systems did not suit the complexity of the printing industry well and printers' requirements of IT solutions differed from those of other industries (Gehman, 2003; PrintCom & Mason, 2005). Industry specific ERP systems were developed for the printing industry. These are known as print management systems or MISs. Other variants of the terms are computer management system, print MIS, and print-specific MIS (Gehman, 2003; Network PDF, 2007; PrintCom & Mason, 2005; Ruggles, 1996).

Despite the access to print-specific MISs, there are a few printing companies using generic ERP systems successfully. Those are mostly large multi-plant companies with uniform and predictable production (PrintCom & Mason, 2005). According to a study conducted by Cost and Daly (2003), the rate of small companies using ERP systems is 5%, and the rate of larger companies is less than 20% (p. 4).

Expensive hardware in the 1960s and 1970s made MISs affordable only for a few large printers. As prices for hardware dropped, more companies could start using the systems, but the capability, user interface, general functionality, and flexibility were poor and required extensive development to reach the standard of today's print MISs (Goldman, 2007).

In 2003, Gehman (2003) reported that there were more than 20,000 installations of MISs worldwide in printing companies, and the number continually increases. The systems can be purchased as off-the-shelf solutions from the many MIS vendors, but they are generally expensive. The alternative is that companies build their own IT structure (Gehman, 2003). There are more than 50 different MIS packages available for the printing industry, and a large number of stand-alone applications such as estimating, scheduling, and order entry (Network PDF, 2007). However, a few MIS providers dominate the market (PrintCom & Mason, 2005).

Definition of MIS

In a nonprinting environment, the term MIS is typically used for financial reporting applications supporting middle management (Laudon & Laudon, 2007). Smyth (2005) defines an MIS as "a computerized system to control all financial information to aid the management function" (p. 693). He adds that data collection and analysis is the base of an MIS. PrintCom and Mason (2005) define an MIS as "a computer-based method of accumulating and processing information for managing a business" (p. 241). Further, they develop the definition of a print-specific MIS as a "system designed specifically to support the needs of printers" (2005, p. 241) and a system that "provides, at minimum, the capability of producing estimates, entering job orders, and issuing job tickets" (2005, p. 7).

The confusion of terms seems to be present among printers as well. PrintCom and Mason (2005) found that some printers call their inventory control systems, accounting packages, mailing or fulfillment systems, and maintenance programs MISs, while they are in fact rather limited specialty systems and not print-specific MISs. According to PrintCom and Mason, the following elements should be included in a fully integrated print MIS:

1) Electronically controlling a job from entry to invoice while monitoring labor and material costs/performance.
2) Links estimating and planning information to job ticket preparation, scheduling, purchasing/inventory, shipping and other production areas.
3) Uses real time data collection to update schedules, job location, material usage, labor time and other productivity components.
4) Creates on-screen and printed reports that provide current and accumulated information on individual jobs and plan performance trends. (p. xiii)

In the context of JDF, MIS is a frequently used term. On the CIP4 website, it is defined as:

> The functional part of a JDF workflow that oversees all process and communication between system components and system control. In JDF this is used as an umbrella term that may include workflow, production management, and pressroom management systems, as well as print MIS systems, and should not be confused with the broader usage of MIS or Management Information systems. The JDF usage of “MIS” does NOT require management reporting, financial systems, accounting, or other functions implied by the broader general usage of MIS.
> (CIP4, 2007, Glossary Chapter)

MISs’ Role in CIM

The print-specific MIS functions as the communication hub in a printing organization, as it collects and shares information from different departments in a relational database. It can keep records of all jobs and other operational activities and allows management to run the business on the basis of data (Gehman, 2003; Network PDF, 2007; PrintCom & Mason, 2005). The MIS is an indispensable tool for printers as they strive toward implementation of CIM (Network PDF, 2007). The MIS has been claimed as the "key ingredient" (PrintCom & Mason, 2005, p. 79) and "core component" (Lamparter, 2007, p. 15) in a CIM effort. While partly integrated workflows can be achieved without an MIS, a fully integrated print shop requires a comprehensive MIS (PrintCom & Mason, 2005).

Module Structure

The MISs of today comprise all processes involved in print production, from order entry to shipping and invoicing. The systems are commonly divided into scalable modules. Some modules can be run as separate applications to achieve a specific function, while others are dependent on another module (Network PDF, 2007; Ruggles, 1994; Smyth, 2005). Ruggles divides the modules into two major groups: accounting and production. Included in the accounting group are modules such as invoicing, payroll, accounts receivable and payable, bookkeeping (general ledger functions), and financial statements (Gehman, 2003; Ruggles, 1994). Gehman claims that "the most successful and profitable printing companies today are those that place a high importance on their accounting and financial data" (p. 31). In the production group are modules such as estimating, order entry, scheduling, shop floor data collection, job costing, shipping, inventory, purchasing, and reporting (Gehman, 2003; Network PDF, 2007; Ruggles, 1994). The estimating module comprises the core of an MIS (Network PDF, 2007), while the data collection module is a key part of CIM and production management (Gehman, 2003). The scheduling module requires electronic information from the estimating module and the shop floor data collection module. The collected shop floor data need to be in real time (Ruggles, 1994).

Benefits of Utilizing an MIS

The major benefit of utilizing an MIS is improved operational efficiency (Gehman, 2003; Goldman, 2007; Smyth, 2005). The printing business is complex and requires a large amount of detail. An MIS allows fast access to detailed real-time production information that benefits estimators, sales personnel, and production managers. It allows for effective decision making and fast profitability analysis. Accurately captured and analyzed operation data allow for better control of costs and more accurate job estimates, preventing further errors and waste (Gehman, 2003). Through e-commerce, remote sales staff, customers, and suppliers may also be allowed access to improved efficiency (Smyth, 2005). With a single point of data entry, redundancy and duplication are reduced (Faust, 2007; Smyth, 2005). This results in less need for reentering data and therefore reduced labor-intensive work (PrintCom & Mason, 2005; Smyth, 2005). Less redundancy and more up-to-date information in the systems reduce errors caused by late information about changes (PrintCom & Mason, 2005). Reduced manual job tracking saves time (Gehman, 2003).

PrintCom and Mason (2005) found that an MIS implementation is necessary for many printers to keep up with their customers' requirements of short delivery cycles and digital workflow. The lower labor costs and shorter turnarounds that an MIS can bring are critical for being competitive.

Production data from finished jobs can help identify bottlenecks in the process, determine which customers are profitable, identify what kind of jobs are profitable, identify equipment that does not perform adequately, and determine whether press problems are caused by consumables or by mechanical malfunctions (Gehman, 2003).

Constraints for MISs

The benefits are difficult to quantify and many printers want to see hard evidence before investing (Goldman, 2007; PrintCom & Mason, 2005), especially since the systems are expensive to purchase (Gehman, 2003). Another obstacle for investment is the implementation process, which is costly, time consuming (Faust, 2007; Smyth, 2005), and complicated because it involves many changes for the organization that are challenging to manage (Smyth, 2005). The future utilization is dependent on printers' initiative in updating their systems and installing JDF-enabled equipment that can be integrated with the MIS and an automated workflow (PrintCom & Mason, 2005). However, the print management itself, not technology, is the largest inhibitor for not using an MIS to run the business (Lamparter, 2007). There is a lack of knowledge, attitude, and interest in using computers and data to manage the plants (Lamparter, 2007; PrintCom & Mason, 2005).

The Status of Today's Usage of MISs

The printing industry uses MISs too passively and mostly as tools for handling accounting and cost requirements, as well as other administrative processes, not for managing the business by measuring, controlling, and developing the business. This leads to delays in identifying productivity problems and overtime, and causes these businesses to spend more money than necessary (Goldman, 2006b, 2007; PrintCom and Mason, 2005; Vision in Print, 2006). Many companies still do estimating on spreadsheets. It seems to be "electronic" but is far from the sophisticated process a print MIS provides (Gehman, 2003; PrintCom & Mason, 2005). However, the mindset is changing and printers are starting to run their businesses based on data (Goldman, 2007). Electronic (on screen) job tickets, the medium for transferring information and the tool to provide all departments with the latest updated information, are not utilized properly (Goldman, 2006b, 2007). Kipphan (2001) claims that most printers lack an overview of the jobs in production and therefore have no control of delays or whether the jobs meet the estimations.

In 2004, PrintCom and Mason (2005) estimated the number of print-specific MISs in place in commercial printing plants with digital and four-color or larger lithographic presses. The estimate, which follows, is based on information from manufacturers and print company surveys. The penetration percentage is presented in the parentheses:

- *Sheetfed presses* – 9,200 printing plant locations, 5,000 MISs (54%)
- *Web presses, heatset* – 900 printing plant locations, 635 MISs (71%)
- *Web presses, nonheatset* – 2,350 printing plant locations, 900 MISs (38%)
- *Web presses, narrow web* – 600 printing plant locations, 250 MISs (42%)
- *Digital presses, over 50 ppm* – 2,800 printing plant locations, 1,700 MISs (61%)

PrintCom and Mason’s (2005) findings indicate that 54% of the 15,800 integrated automation-eligible plants (lithographic printers using four or more colors on two or more presses and employing more than 20 people and commercial digital printing plants) have a functional MIS to support automation. However, between 5,500 (35%) and 6,500 (41%) of these fail to use the systems fully. They lack modules, or fail to maintain and update the existing modules. It was also found that small, sheetfed lithographic printers that are using MISs generally have low end, nonscalable systems or use spreadsheets for their business processes. PrintCom and Mason forecast a 69% penetration rate of MISs in 2010 due to a decrease in the number of printing establishments and an increase in installed MISs (2005).

PrintCom and Mason’s estimate of the MIS presence in printing companies is supported by Cost and Daly (2003), who found that 59.1% of the respondents in their study employed MISs. Vision in Print (2006) found that the major reason for investing in MISs is to improve administrative efficiency, in particular estimates. Estimating modules are the most common module installed, followed in order by costing, order processing, and scheduling.

As mentioned earlier, two of the major benefits in using MISs efficiently are the capability to avoid re-keying data and the elimination of redundancy of data by using one centralized database (Faust, 2007; Smyth, 2005). However, Cost and Daly’s (2003) survey shows that over 60% of responding companies have two or more unconnected databases with the same information residing in more than one location in the system.

Kipphan (2001) and Goldman (2006b) emphasize the importance of having real-time data to efficiently run the plant, but both report on the lack of it. A survey conducted by PrintCom and Mason (2005) shows that about half of the responding printers perform neither machine nor labor shop floor data collection on a regular per job basis. Of those who collect data, 30% to 35% use features that automatically feed the data into an MIS, while 35% use manual input. Furthermore, respondents indicated that the collected data is usually only analyzed periodically or when a problem needs to be investigated. Printers also express a lack of confidence in the collected data. Larger companies with more sophisticated MISs tend to collect shop floor data more often than smaller companies. (PrintCom & Mason, 2005).

Scheduling

Kraebber and Rehg (2005) claim that efficient manufacturing requires process planning, production scheduling, inventory management, and capacity planning. The printing industry agrees with the importance of the scheduling function. It has been described as the core part (Gehman, 2003), the nerve center (Goldman, 2006a), and the most vital part to manage in a printing plant (Bann, 2007). Further, Gehman (2003) states, "No printing operation of any size can function without scheduling" (p. 59).

Money, personnel, and machinery need to be scheduled as well as materials – particularly paper – and operations such as proofing, error fixing, packaging, and distribution (Bann, 2007; Gehman, 2003; PrintCom & Mason, 2005). Independent of the scheduling technique, optimal scheduling should be a goal for every printer. Optimization helps minimize costs and increases production, therefore increasing profitability (Gehman, 2003).

The schedule must be realistic, attainable, and reasonable. It is not supposed to be a wish list (Kraebber & Rehg, 2005). Poor scheduling can cause critical issues for the printing plant. It increases idle time when equipment is not in use, and, if not enough time is allowed for each operation, it causes stress, unnecessary overtime, and late deliveries. The bindery especially seems to face these issues far too often when the time between the press run and estimated delivery date is too short (Merit, 1992). Customers want service, and "service means meeting all the schedule dates and the final delivery dates" (Bann, 2007, p. 160). Late deliveries are, according to Merit (1992), the main reason why print buyers leave their printer for another.

Manual Scheduling

Traditionally, scheduling has been executed manually, often with help of whiteboards or magnetic boards (Gehman, 2003, PrintCom & Mason, 2005). Many print-service providers still use manual scheduling even if their print management systems have a built-in scheduling function. In some cases, the printers use both the manual scheduling tool and the limited computerized scheduling feature in their system (Gehman, 2003).

A manual scheduling system has some weak spots. Collection of data and reformatting to fit the manual scheduling system are time-consuming and often only useful for the planner. Additionally, input error is more common since data have to be entered in more than one place. Also, information regarding important events such as changes and production problems might reach the personnel too late if it does not get through the workflow efficiently. The overall picture can be difficult for others to see, because the production managers or schedulers may keep some important information in their heads. A lack of interconnectivity between systems can lead to slow or faulty decision making (Gehman, 2003).

According to PrintCom and Mason's (2005) experiences, many printers are excellent expediters that can manage to make quick last-minute changes in a manual scheduling system to complete an important job. Unfortunately, this is a very short-term solution that many times leaves a "wake of chaos."

Computer-Assisted Scheduling

Static, sometimes homegrown, spreadsheet applications are a form of computer-assisted scheduling, but share most of the constraints of manual systems (Gehman, 2003). Lately, software vendors have begun providing more sophisticated scheduling programs that go beyond the loading programs, but few are in actual use (Gehman, 2003; PrintCom & Mason, 2005). This application is called dynamic scheduling and is defined by PrintCom and Mason (2005) as "the process of automatically adjusting a schedule to accommodate changes" (p. 240). Computerized scheduling modules are generally supplied with print MISs for a small fee or no additional cost. The built-in modules vary from very simple scheduling tools to advanced full-featured ones (Gehman, 2003).

The requirement for a well functioning computer-assisted scheduling program is real-time shop floor data collection and job tracking. It is essential for input information to be updated in real time (Goldman, 2006b; PrintCom & Mason, 2005). Slow data transfer causes many scheduling execution problems (Kraebber & Rehg, 2005).

Computer-assisted scheduling and shop floor data collection are not new for the printing industry. They emerged 20 years ago when computers became the mainstay of prepress and typesetting technologies. At that time, the need for computer-assisted scheduling was not obvious. When the printing business faced a downturn in the late 1990s that lasted through 2001, the pressure to reduce costs, achieve faster deliveries, and produce better custom service forced printers to start looking for solutions (Goldman, 2006b).

Benefits of Computer-Assisted Scheduling

The nature of today's throughput, with a large number of short runs, fast deliveries, and continual last minute changes, is seen by many as an argument for utilizing computer-assisted scheduling, regardless of the size of the printing company (Kipphan, 2001; Vision in Print, 2006). Gehman (2003) and PrintCom and Mason (2005) agree upon the efficiency gains a computer-assisted scheduling system can bring. Scheduling software allows the printer to be more proactive because of the ability to quickly show the impact of changing the order of jobs and to benefit from determining the difference between a switchover (the same ink and press configurations are used for more than one job in a sequence) and makeready (Gehman, 2003). Cycle times and costs can be reduced, and the percentage of jobs delivered on time increases (PrintCom & Mason, 2005).

Printing productivity consultant Dickeson (2002) reports, “The true secret of efficiency, productivity and profitability for manufacturing – for printing – is to be found in the speed and continuity of process throughput” (p. 68). Udi Arieli, expert in scheduling, emphasizes the importance of throughput for a printing company and claims it is more important than job costing. Furthermore, he argues that the scheduling function is a scientific tool that can improve a company’s customer satisfaction, competitiveness, and profitability (O’Brien, 2003). Since scheduling allows for better resource allocation, equipment and machinery can be utilized more efficiently, which increases throughput (Cross, 2006; O’Brien, 2003).

Sam Shaffer, general manager of Marketing Services by Vectra, has been running the dynamic scheduling program Printflow from Electronics for Imaging (EFI) since May 2004. He reports a 20% improvement in throughput and says, “Dynamic scheduling, is one of the most important elements you can have as part of your MIS” (Electronics for Imaging, 2005). The printer LAgraphico in California increased its throughput by 10% to 15% after implementing EFI’s Printflow (Cross, 2006).

In a case study of 11 U.K. printers, conducted by Vision in Print (2006), only two companies were using full scale computerized scheduling systems. The benefits those companies have gained from their scheduling programs are so significant that they find the scheduling programs absolutely necessary in their continuing business. The companies report benefits such as increased pressroom capacity, better control and predictability, generally improved administrative efficiency, and improved quality and speed of internal communications with reduced need for production meetings.

Constraints for Computer-Assisted Scheduling

Some users of computer-assisted scheduling systems value them and praise their capability of managing quick turnarounds and complex jobs; others have the opposite opinion and claim that the characteristics of today's jobs, with short runs, fast deliveries, and many last minute changes, make the use of scheduling systems difficult. They claim those systems are too slow and too inflexible to handle today's jobflow. Moreover, according to those companies, the amount of data input required is too great (Vision in Print, 2006).

Vision in Print (2006) states that the criticisms of computer-assisted scheduling may be valid for those systems that are operated as separate systems with poor integration and if no shop floor data collection system is used. However, Vision in Print somewhat agrees with the critics, "Computerized production scheduling does not seem to suit everyone" (p. 51). Goldman (2006a) has found that "mismatched estimating and scheduling standards are the Achilles' heel of many printing plants" (p. 45).

Machine-specific characteristics, such as an abnormal tendency for ghosting and inconsistency of dot gain along the cylinder, influence the types of jobs – depending on the layout and design – that can be run on the press. Human judgment is needed, which is a constraint for full utilization of dynamic scheduling (PrintCom & Mason, 2005).

Implementing dynamic scheduling systems requires an organizational change. Some print managers claim automation of scheduling cannot be carried out, and some plants have built an organizational culture in which a change is next to impossible (PrintCom & Mason, 2005).

The Status of Today's Usage of Computer-Assisted Scheduling

The larger the plant, the greater the need for computer-assisted scheduling. In general, larger plants have a more formal planning and scheduling process (Kipphan, 2001; PrintCom & Mason, 2005). Surprisingly, some plants, in particularly small and mid-size companies, may not have any kind of formal planning and scheduling process (PrintCom & Mason, 2005).

Opinions about utilization of computer-assisted scheduling programs vary. Some claim electronic scheduling systems and computer-generated estimates and job entry are standards in most printing plants (Faust, 2007). In a study conducted by PrintCom and Mason (2005), it was found that larger printing plants usually have installed a scheduling module, while smaller plants do a less thorough manual planning and scheduling, or they just expedite the job as soon the proofs have been approved. Vision in Print (2006) agrees that particularly small companies do not utilize computer-assisted scheduling. A survey conducted among U.K. printers shows that 35% of respondents (small as well as large companies) use some form of planning and scheduling function within their MIS, but very few use full scale computer-assisted scheduling. Manual loading boards are still used by 80% of the respondents, and 30% of the respondents have to rework estimating data at some point to fit the scheduling system.

Goldman (2007) states that scheduling is underutilized and reveals that many companies own scheduling modules without installing them. In the 2006 issue of *GATFWorld Forecast* he claims, "Less than 10% of the printers are using their MIS for computer-assisted scheduling" (p. 37). In the same magazine one year later, he states that the figure has increased and that less than 15% of printing plants now have installed computer-assisted scheduling, excluding the largest of printing companies (Goldman, 2007).

Lean Manufacturing

Lean manufacturing (also termed lean production or lean) is a strategic initiative and approach that continuously improves efficiency by eliminating operations that do not add value for the customer. Non-value-added activities are often referred to as waste (Cost & Daly, 2003; Jones & Womack, 2005; Kraebber & Rehg, 2005). The goal of lean manufacturing, according to Hall, High, McNaughton, and Sharma (2001), is to "produce the highest quality at the lowest total cost in the shortest lead time, with flexibility to respond to changes" (p. 87). But most importantly, the whole point of lean manufacturing is to satisfy the customer (Jones & Womack, 2005). Ryan McMillian (2007), ACFC (stands for At the Customer, For the Customer) Lean Leader at General Electric, describes lean manufacturing as a focused strategy to eliminate waste, increase speed, reduce variation, reduce cost, simplify the process, and consistently meet customer requirements. This improves customer satisfaction through reduced cycles, better delivery, increased capacity, better quality, and improved productivity.

Daniel Jones and James Womack first used the term lean manufacturing in their book *The Machine That Changed the World*. The book describes Toyota's manufacturing philosophy, called the Toyota Production System, that enabled the company to produce affordable high quality cars fast, despite expensive raw materials and limited production lines (Allen & Robinson, 2001).

Lean Manufacturing in the Printing Industry

The approach works in any industry, company, or country (Jones & Womack, 2005), and lately, the printing industry has started to show its interest in a number of lean initiatives that are being introduced (Cooper & Keif, 2007). Both the competition and the costs in the printing industry are increasing (Davis & Gleeson, 2007). Lean manufacturing provides a way to do "more and more with less and less" (Jones and Womack, 2003, p. 9), by converting waste into value. Cooper and Keif (2007) believe lean manufacturing is necessary for printers' long-term survival.

The study *Digital Integration and Lean Manufacturing Practices of U.S. Printing Firms* (Cost & Daly, 2003) indicates that printing companies believe CIM and lean manufacturing are important for the future profitability of their business. They also believe that they are not knowledgeable enough in those areas.

Many of the benefits of lean manufacturing are intangible and difficult to measure (Meier, 2001a). However, printing companies have experienced less waste, reduced inventory, improved quality, reduced lead times, reduced down time on equipment, reduced number of overruns, and a better working environment as a result of the adoption of lean manufacturing (Cost & Rothenberg, 2004; Q&A, 2007).

Lean Manufacturing and CIM

Lean manufacturing requires neither technology nor computer systems, but when implementing CIM and new technology, it is highly recommended to first analyze and simplify the processes to eliminate waste (Kraebber & Rehg, 2005; Laudon & Laudon, 2007). Cost and Daly (2003) claim lean manufacturing is the necessary foundation for implementing CIM efficiently.

Kraebber and Rehg (2005) have experienced cases in which CIM and computer-based systems seem to be replaced by lean manufacturing initiatives or similar approaches. But they believe CIM and computer-based systems can complement and support strategies such as lean manufacturing and help eliminate waste and meet customers' requirements (Kraebber & Rehg, 2005). CIM can be a part of lean manufacturing since it has the ability to create automated workflows that reduce the risk for human-caused errors and variation, and it can also be used to reduce redundancies in the workflow (Cooper, 2006). However, technology in a lean organization should support the process by directly adding value to the operation or assisting the operator. If that is not the case, the technology actually risks bringing waste into the systems (Allen & Robinson, 2001).

Waste – Any Non-Value-Added Activity

The actions taking place in any organization can be divided into the following three groups: activities that add value to the product (i.e., activities the customers are willing to pay for), activities that do not add value but are necessary (i.e., billing), and activities that do not add value (Crabbtree, 2007).

Non-value-added activities are also referred to as waste. Jones and Womack (2003) define waste as any human activity that absorbs resources but creates no value. Kraebber and Rehg (2005) expand the definition of waste to "every possible operation, move, or process that does not add value to the final product" (p. 30).

The terms "added value" or "value added" used in lean manufacturing describe "those activities that the customer is delighted to pay for" (Cooper, Keif, & Macro, 2001, p. 91). In a nonlean manufacturing context, the terms are defined with a specific mathematical formula (Value Added = Sales – [materials cost + outside services]) that can be used as a direct measurement of the company's wealth (Vision in Print, 2006). The Graphic Arts Technical Foundation/Printing Industries of America (GATF/PIA) (2003) defines value added as "a technical term for sales of a company's own manufacture" (p. 6).

The printing industry is facing non-value-added factors such as delays, lost machine time, long set-up times, excess inventory, rework, disorganized work, inspection, and repair (Allen & Robinson, 2001; Huskins, 2007). Huskins claims that it is not unusual for printing companies' production lead time to be made up of 90% non-value-added activities. This somewhat disagrees with Cooper, Keif, and Macro's (2007) finding. They claim that the percentage of non-value-added activities in the printing process is lower: between 40% and 60%.

A key element in lean manufacturing is the use of measurement. The right measurement shows the current state in performance and waste (Meier, 2001b).

<u>The Wastes.</u> Taiichi Ohno, frequently referred to as the father of the Toyota Production System, identified seven categories of waste, which are now the cornerstones of today's lean manufacturing strategy. In later years, a complementary eighth waste has been introduced (Cooper, Keif, & Macro, 2007; Jones & Womack, 2003). The wastes are:

1) Defects: Products that do not meet the customer's requirements and/or diverge from the specification are defects, as well as material spoiled in the process (Cost & Daly, 2003; Dixon, 2001a). The average spoilage rate in the printing industry today is 2% (Prince, 2007).

2) Overproduction: Occurs when more products are produced than the customer demands. It is perhaps the most costly waste because it encompasses all the other wastes in the extra production (Jones & Womack, 2003; Meier, 2001b).

3) Inventory: Is anything of value awaiting further processing or consumption, such as work-in-progress (WIP), raw material, and finished goods. Inventory consumes resources such as space, capital, and human resources (Cost & Daly, 2003).

4) Over-Processing: Is any step that is not actually needed, according to the customer requirements, and therefore adds no value to the product (Cooper, Keif, & Macro, 2007; Cost & Daly, 2003; Jones & Womack, 2003).

5) Movement: Is unnecessary movement of people. The plant layout determines the level of movement. An example is how far employees have to walk to get the tools or raw materials necessary to do their job (Cooper, Keif, & Macro, 2007; Jones & Womack, 2003).

6) Transport: Poor plant layout also contributes to transportation waste. To move goods and materials from one place to another does not add value (Cooper, Keif, & Macro, 2007; Cost & Daly, 2003; Jones & Womack, 2003).

7) Waiting: Employees waiting for equipment to finish its work or waiting for an upstream activity or product to be handed off is a waste (Cost & Daly, 2003).

8) Underutilized Resources: Includes both people and technology. Examples of underutilization of people are the waste of good ideas; failure to grow and develop people; not drawing on people's talents, knowledge, and skills; not listening or not talking to people (Allen & Robinson, 2001; Compton, 2006).

<u>The Five Principles of Lean Manufacturing</u>

After thorough interviews and analysis of the Toyota Production System and other companies performing lean strategies, Jones and Womack (2005), summarized the findings into the following five principles for leaner organizations:

<u>Specify/Define Value.</u> Value is created by the producer (Jones & Womack, 2003), but only the customers, from their perspective, can define it. The value of each specific product or operation should be determined (Allen & Robinson, 2001; McMillian, 2007).

Many times, the company thinks it knows what the customer values but is wrong, which causes waste (Allen & Robinson, 2001).

Customer satisfaction is important but difficult to measure. Moreover, dissatisfaction is associated with a cost. Meier (2001a) suggests four indicators for customer satisfaction: *Complaints or defects* per 1,000 items produced; *Number of past-due orders*; *Lead-time*, because shorter lead times increase the chance to quickly meet the customers' demand and reduce inventory cost; *Delivery reliability*, meaning the percentage of correct and complete orders delivered on time.

<u>Map the Value Stream</u>. Map all the events and activities that are involved in the process of bringing a product or service to the customer. The map is based on hard facts and is a helpful tool to locate the waste. Once waste is located, it is easier to develop a plan for eliminating or reducing it (Hall, High, et al., 2001; Huskins, 2007). The value stream mapping usually comprises two different events: a current state map (Figure 1) and a future state map. Some companies choose to draw up a third map: the ideal value stream map. A comparison between the ideal value stream map and the current state map more clearly shows the waste (Cooper, Keif, & Macro, 2007; Hall, High, et al., 2001).

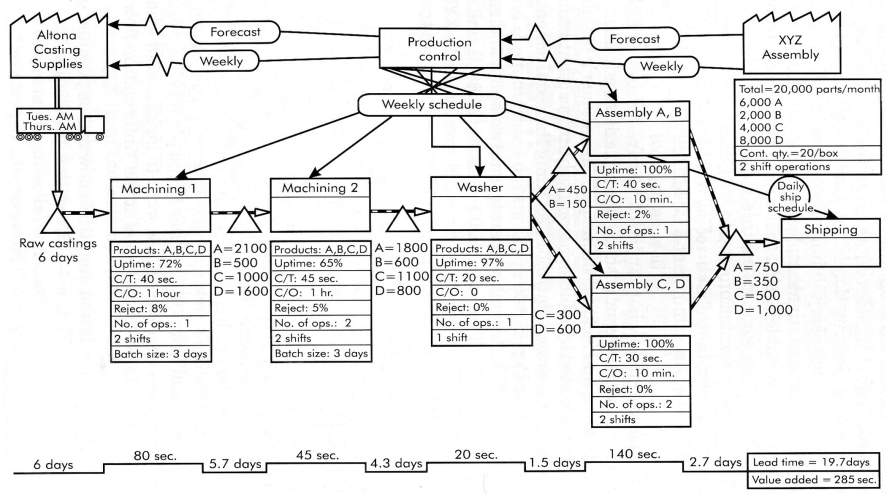


Figure 1. Example of value stream mapping of the current value chain.
From Chapter 4: Mapping the value stream, by P. Hall, M. High, A. McNaughton, and B. Sharma, 2001, in J.Allen, C. Robinson, & D. Stewart (Eds.), *Lean manufacturing: A plant floor guid*e, p. 76, Dearborn, MI: Total Systems Development.

Data is preferably collected with the help of a pen and paper. The following are examples of shop floor data that should be collected: scrap rates, inventory levels, machine cycle times, and changeover time (Hall, High, et al., 2001).

Establish Flow. Manufacturing processes can be executed two ways: in a batch-and-queue model or by a flow process. The flow process describes a continuous movement of material, products, and information down the value stream. Any stop or reverse is waste (Allen & Robinson, 2001; McMillian, 2007). A typical example of such a reverse flow in the value stream is the activity of a proof being sent back to a customer (Whittaker, 2007). The major benefit of the flow process is the positive impact on cash flow and inventory (Dixon, 2001b).

Implement Pull. The slogan “make what we sell, not sell what we make” clearly illustrates the pull-based model (Laudon & Laudon, 2007). When the pull-based model is implemented, only those products that the customer requires are produced, and no action is taken until the downstream process initiates it. This prevents batches and queues (Allen & Robinson, 2001; McMillian, 2007), and enables just-in-time (JIT) supplier management (DeBold & O’Meara, 2001).

Improve to Perfection. The goal should be a perfect process; but in reality, there is always waste. The tactic to reach perfection is continuous improvement to eliminate waste so all activities create value for the customer (McMillian, 2007). When all of the preceding four principles are established, the firm should start over again in an endless search for perfection (Jones & Womack, 2005).

Lean Tools

The lean principles are simple, but to become a lean enterprise is not an easy project. A stable lean organization is built through small steps of success (Allen, 2001a; Allen & Robinson, 2001); or, as Cooper and Keif (2007) express it, “Transforming a company into a lean enterprise is a marathon, not a sprint” (p. 22).

There are a number of different tools provided to support a lean implementation. But without change management, an empowering management style, and teamwork, the project risks stagnating (Cooper & Keif, 2007; Cooper, Keif, & Macro, 2007). Some of the tools used in lean manufacturing are described here.

The 5S strategy was used in the Toyota Production System, and the five S's originally came from five Japanese words that are translated into English (Cooper, Keif, & Macro, 2007; Thomerson, 2001b). The process starts with an organization of the items in an area. Keep what is needed and throw out the rest (*sort*). Decide where the items will be located and mark up the areas to set space limits to prevent accumulation of items (*stabilize*). Clean up the work area and find preventive methods for avoiding accumulation of dirt, dust, fluids, and other debris (*shine*). *Standardize* the procedure for keeping the workplace organized and clean. In the *sustain* phase, the correct procedures have become a habit and continuous improvements to keep the workplace clean and neat are taking place constantly (Cooper, Keif, & Macro, 2007; Thomerson, 2001b).

Error Proofing means that the processes are built so that no defects occur, or at least so that defects can be detected once they occur (Cooper, Keif, & Macro, 2007; Dixon, 2001a).

A *Kaizen event* provides a jump-start to improve processes in just a few days. It is a tool for getting started with any lean initiative, such as performing 5S on a specific area, and developing quick changeover activities. In a Kaizen event, a cross-functional team is assembled. The team's goal is to identify, analyze, and solve issues that create waste (Cooper & Keif, 2007; Cooper, Keif, & Macro, 2007).

Standardized Work is the process of defining and documenting any repeatable sequence in an organized, safe, and efficient way, with a minimum of waste. Standardization ensures that the processes are constantly performed and that every employee works in a safe and efficient manner (Thomerson, 2001a).

The objective of the *visual factory* is to share information in a quick and easy way so that abnormalities can easily be detected by anyone. A standardized visual language including elements such as color-coding, layouts, and signboards makes it possible to accomplish this. Instructions, safety regulations, and locations in which tools and material belong are examples that can be visualized (Thomerson, 2001b).

The purpose of *quick changeover* is to "reduce the time the machine is not running" (Centers & West, 2001, p. 307).

TPM – Total Productive Maintenance is the activity of standardizing maintenance and making it a built-in duty in every employee's daily routines. The goal is to find weak points in the equipment and machines before they cause waste and defects (Cooper, Keif, & Macro, 2007; Robinson, 2001).

Effective *Problem Solving* prevents problems to appear again. A standardized systematic approach, such as the plan-do-check-action cycle, helps the team keep on track (Hall, Manley, & Renick, 2001; Mussman, 2001).

Policy deployment includes setting annual objectives, establishing a vision, and formulating a long-term plan. It is a method to align everybody before an implementation can take place (Stewart, 2001b).

Conclusion

The printing industry experiences increased competition mainly from globalization and the usage of the Internet. In addition, there is an increase in costs to expect, and customers demand faster, higher quality, and more complex jobs, while demanding lower prices. It has become essential for printers to increase their efficiency and productivity to be successful and sometimes even to survive.

The literature discusses two ways to achieve better performance: with support of technology, such as CIM, MISs, and scheduling software, or with a quality initiative, such as lean manufacturing.

CIM is the integration of systems to achieve automation. A core component of CIM is the MIS, which functions as the communication hub in the printing organization. Between 50% and 60% of the commercial printers in the U.S. use some kind of MIS. Many MISs have built-in scheduling features, but less than 15% of U.S. printers are utilizing them. The scheduling function is a core part of a printing plant, and it can help minimize costs and increase throughput if it is properly executed, whether it is manual or computer-assisted. Users and vendors of scheduling software emphasize benefits such as increased efficiency, increased on-time deliveries, increased equipment and machine utilization, reduced cycle times, and better control and predictability.

Lean manufacturing is an increasingly popular quality initiative that shares many objectives with CIM, MIS, and computer-assisted scheduling. The main objective of lean manufacturing is to eliminate waste, also called non-value-added activities. Examples of waste in the printing industry are: delays, long set-up times, excess inventory, rework, and inspections. Some authors claim lean manufacturing to be necessary for printers' long-time survival (Cooper & Keif). Printers using the strategy have experienced reduced waste, reduced inventory, reduced lead times, reduced overruns, improved quality, and a better working environment.

Only two books mention anything about combining a technology strategy with a quality initiative strategy. In the book *Computer-Integrated Manufacturing* (2004), Kraebber and Rehg believe that CIM and computer-based systems can complement and support strategies such as lean manufacturing and help eliminate waste. Furthermore, Cost and Daly (2003) claim lean manufacturing is the necessary foundation for implementing CIM efficiently.

Chapter 3

Research Questions

The printing industry continuously works to improve efficiency and productivity in order to increase profitability and gain competitive advantages. Many different strategies and solutions have been introduced to printers over the years, and the results vary. This research focuses on the usage of computer-assisted scheduling and its potential for reducing waste within a lean manufacturing perspective in a printing plant. Two research questions were developed:

Research Question 1

Many sources agree about the significant benefits in efficiency and productivity that can be gained by utilizing computer-assisted scheduling through an MIS. Many MIS vendors today provide built-in scheduling systems. However, the level of usage is low among printers. This situation leads to the first research question:

Why are printing companies that own the computer-assisted scheduling module not using it?

Research Question 2

Lean manufacturing, which includes a strategy to reduce waste, is an increasingly popular strategy to improve efficiency and productivity in the processes. Computer-assisted scheduling may be a relevant tool to enhance a lean manufacturing initiative by helping reducing waste. The second research question is as follows:

Are companies that are using computer-assisted scheduling different in performance on the following compared to those that do not use computer-assisted scheduling?

- *Equipment utilization rate*
- *Throughput time*
- *The time a job spends between different operations/functions*
- *On-time deliveries*
- *Frequency of production meetings*
- *Rate of short makereadies*

Chapter 4

Methodology

Qualitative Research Methodology

A qualitative methodology has been used for this research because the purpose of the research was to *capture broad patterns* of the current state, which is also the objective in qualitative methodology. A quantitative research methodology would have enabled a valid generalization of the results, which would have been valuable. However, it was found that the use of the quantitative methodology was not feasible for this study (further explanation is provided in Appendix A).

Data for this study were collected through a survey sent by email. Only commercial printers in the U.S. are included in the research.

The Survey – Email Questionnaire

The email questionnaire (Appendix B) was sent to 114 commercial printing company locations across the U.S. The purpose of the survey was to investigate whether a trend or pattern could be observed among the responding companies regarding their usage or nonusage of a computerized scheduling system.

Selection of Participants and Collection of Contact Information

The main criterion for the companies to participate in the study was the presence of an MIS in their daily business. This criterion had two objectives:

1) To increase the chances of reaching companies that own computerized scheduling software.
2) To allow a more accurate comparison of company performance between those that are using scheduling software and those that are not because the companies are at a similar technological level with regard to an MIS.

Initially, a list of companies that would be suitable to participate in the survey – commercial printing companies in the U.S. that are using an MIS – was compiled by collecting information from different websites, such as MIS vendors' websites, the search engine Google.com, WhatTheyThink.com, *American Printer*'s website, and the ProQuest Database provided by the Rochester Institute of Technology (RIT) library.

The *2007 Survey of Management Information Systems* (Bohan & Mooney, 2007) provided a list of 39 vendors of MISs for commercial printers in the U.S. This publication was used as a source to increase the chances for a broad representation of different MISs among the participants.

When the list of company names was compiled, each company's website was visited with the purpose of collecting the name and email address of the operations manager, director of operations, plant manager, scheduling manager, or other person with an adequate title to answer the survey. The companies that did not provide such information on their website were called.

The final list contained names and contact information for suitable respondents at 114 printing company locations.

Response Rate

The fact that email surveys usually yield low response rates (C. Sartori, personal communication, September, 2007) was kept in mind when planning the design of the survey. The following guidelines were established and followed to encourage a high response rate. The survey:

- Was conducted in a simple manner.
- Was designed in a clean and professional style.
- Consisted of few questions.
- Contained mainly “check-box” questions and a limited number of “open-ended” questions in which the respondents had to type in text.
- Was sent out so that the respondents received the email in the morning since studies show that online survey invitations sent out in the morning have a higher response rate (Hamilton, 2004).
- Was sent with a cover letter containing a personal greeting with the receiver’s last name (Appendix C).
- Guaranteed confidentiality to the respondents.
- Promised a summary report of the results to the respondents.
- Was followed up by one reminder email to those who did not respond after the first request (Appendix D).

Design of the Survey

A careful attention guided the design of the questions. The printing industry often uses jargon, and in the literature, authors use different terms to describe the same actions and events. In the case where jargon or a potentially confusing term was used in a survey question, the term was accompanied by a definition.

In some cases, especially in Part 2 of the survey, the requested information was of a sensitive nature. Therefore, the questions were formulated so as to avoid negative and emotionally charged wording. An example is Question 17, in which “delivered after the date specified on the order specification” replaced wording such as “missed due-date,” “lack of on-time delivery,” or “late delivery.”

Some questions were designed so that a statement was given and the respondents were asked to agree or disagree with it. These questions were designed so that a neutral response was not possible.

The electronic questionnaire was created in SurveyMonkey.com, an online service for creating electronic surveys and for collecting and organizing the responses. SurveyMonkey.com offers different subscription plans and provides templates for survey design. It also provides the opportunity to create customized designs. The responses are collected automatically as soon as a respondent leaves a started survey or after completion. The collected responses are automatically shown in a summary sheet which can also be downloaded as raw data for spreadsheets.

An email cover letter (Appendix C) containing a link to the electronic questionnaire was sent directly, as often as possible, to the operations manager or person with adequate title at each company location. The cover letter contained a short introduction of the researcher and explained the purpose of the survey.

The questionnaire was designed in such a manner that the next question presented for the respondent was often determined by her/his current answer. This function is called “skip logic” in SurveyMonkey.com. Depending on the respondents’ answers, the survey contained 12 to 16 questions. The survey was divided into the following sections:

Part 1 consisted of three initial questions whose purposes were to determine whether the responding companies were using an MIS or ERP system and, if they were, for how long they had been using it. The third question in the survey was the core question for the research. It sought to determine how many companies own a scheduling module/software and how many of them are using it or not using it. Depending on the answer, the respondent was transferred by the skip logic function in SurveyMonkey.com to an appropriate sub-section of Part 1 containing follow-up questions.

The data collected in Part 1 of the survey was used to answer Research Question 1.

Section 1a contained three questions for those respondents answering that they own a scheduling module/software but do not use it. This section had three questions plus an additional request in which the respondents’ motivation regarding a previous question was determined.

Section 1b contained five questions for those respondents answering that they own a scheduling module/software and use it. The questions sought to determine advantages and disadvantages that the respondents had experienced with their scheduling software.

Section 1c was addressed to the respondents who do not own scheduling software. This section contained two questions and an additional request in which the respondents' motivation regarding a previous question was determined.

Part 2 of the survey was a general section directed to all respondents. It contained eight questions about the printing plant's performance, such as throughput time, number of on-time deliveries, and utilization rate. The last two questions of the survey asked the respondents to identify themselves to avoid receiving a reminder email and asked if the respondents would be willing to participate in a follow-up interview. The data obtained from Part 2 of the survey contributed to the conclusion for Research Question 2.

Sending Out the Survey

Before the survey was sent to the respondents, it was tested on a small pilot group that included both people from an academic environment and people from a printing plant. The final survey was sent out late at night so that the respondents had it in their email inboxes when they came to work in the morning. Respondents received the survey request between Tuesday and Thursday. Mondays and Fridays were avoided because those days are considered to yield a lower response rate. The company locations that did not complete the survey within a week received an additional email again requesting that they complete the survey. The cover letter for the reminder emails was appropriately modified (Appendix D).

Discarded and Manipulated Surveys

The survey was sent to 114 printing company locations. In total, 65 responses were received. Of the 65 responses, 5 were discarded from the study, meaning that, for different reasons that are discussed below, they were not included in the research result and analysis.

Four of the discarded surveys were labeled “anomaly surveys.” These four surveys were the results from two company locations that answered the survey twice with major differences in the responses. Both respondents claimed to own scheduling software when they took the survey for the first time. In their second attempt, they both changed their answers and claimed that they do not own a scheduling module. They both left some comments in the survey that indicated that they are in the process of implementing their scheduling software. Therefore, they probably felt that the questions did not apply to their specific situation. This issue was discussed when designing the survey questions. However, the issue was disregarded because the probability that the participating companies would be in this “middle phase” was low. Even though these surveys were not included in the result, they are still an indicator that companies are in the process of implementing the module/software they own.

The fifth discarded survey was one of two received from the same company location. In this case, there were only minor differences between the two sets of answers. Therefore, the decision was made to accept and include the first survey in the study. The reason for rejecting the second survey was that the respondent had already read the questions once and had more time to think about the answers. Therefore, the respondent might have been biased about the survey the second time. Moreover, intuition says that the first answer is usually the most honest and closest to the truth.

In one case, only part of a survey was used in the result and analysis. Hence it was not discarded and belongs to the group of 60 surveys that were used in the study. The decision to use only the first part of the survey was based on the answer to Question 1 "Does your company location use a print-specific MIS?" The respondent does not use any kind of MIS or ERP system. This fact disqualified the respondent from being compared with other respondents (Research Question 2), which was the purpose of Part 2. However, the respondent still contributed important information for Research Question 1, and therefore the first part was used in the analysis.

Calculations/Mathematical Formulas Used

In Questions 5, 11, and 13, the respondents were given a set of statements to rate according to how strongly they agreed or disagreed with them on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree). For each of the statements, a rating average has been calculated to determine the order of importance of the given statements. The results for these questions are presented in tables. Figure 2 is a snapshot of such a table.

Answer Option	Strongly Agree (4)	Somewhat Agree (3)	Somewhat Disagree (2)	Strongly Disagree (1)	Rating Average	Response Count
Inflexible	35.7%	50.0%	0.0%	14.3%	**3.07**	14
Difficult to implement	21.4%	57.1%	14.3%	7.1%	**2.93**	14
Have not found the right	28.6%	28.6%	28.6%	14.3%	**2.71**	14

Figure 2. Snapshot of a table, showing the design of tables used to present result data for Questions 5, 11, and 13.

The rating average is calculated by taking in account the level of agreement, 1 to 4, according to the following formula:

(Strongly Agree response proportion x 4)
+ (Somewhat Agree response proportion x 3)
+ (Somewhat Disagree response proportion x 2)
+ (Strongly Disagree response proportion x 1)

= Rating Average

Translated into figures according to Figure 2, the formula for the first answer option (“Inflexible”) would appear as follows:

$$(.357 \times 4) + (.5 \times 3) + (0 \times 2) + (.143 \times 1) = 3.07$$

In Question 20, the respondents were asked about the average number of short makereadies and complete makereadies during one day considering all their printing presses and then separately on all their folders. The purpose of the question was to compare the proportion of short makereadies for each individual plant and determine if companies using computer-assisted scheduling software perform differently.

For each respondent, the given number of short makereadies was divided by the total number of makereadies (short + complete) for the particular plant. A higher number represents a higher number of short makereadies. Short makreadies result from planning the job sequence; they are less time-consuming than complete makereadies.

In the analysis of Research Question 2 (based on the data from Part 2 of the survey) a mean value of the performance was calculated for each of the investigated categories and for each of the two groups: users and nonusers of scheduling software. The following formula was used to calculate the mean:

$$Sample\ Mean = \sum(f_i \ x \ M_i)/\ n$$

Where,

M_i = the midpoint for class i (interval i)
f_i = the frequency for class i (interval i)
n = the sample size

Chapter 5

Results

The data received from the surveys is presented in this chapter.

The survey was sent out by email to 114 printing company locations. In total, 65 responses were received. Five of these were discarded and are therefore not included in the results. These are discussed in the Methodology section, Chapter 5.

Of the 60 surveys that were used in the results and analysis, 55 were fully completed. Four respondents completed only the first part of the survey. These responses are included in the survey because they still contribute valuable information to the research. One survey was modified so that only the first part has been included. This is also explained in the Methodology section, Chapter 5.

Part 1

Part 1 of the survey included Questions 1 to 3 and was addressed to all respondents.

<u>Question 1: Does your company location use a print-specific management information system (MIS)/print management system?</u>

Fifty-five of the respondents (85.0%) said they use a print-specific MIS. Eight respondents (13.3%) use a non-print-specific MIS and only 1 respondent (1.7%) does not use any kind of MIS (Table 1).

Table 1. Does your company location use a print-specific management information system (MIS)/print management system?

	Response Percent	Response Count
Print-specific MIS	85.0%	51
Non-print-specific MIS/ERP	13.3%	8
No MIS	1.7%	1
Total:	100%	60

<u>Comment</u>. The result shows a large number of respondents who are using an MIS/ERP system. This was expected because of the method used to obtain the contact information for the participants. The participating companies were selected because it was assumed that they owned some form of MIS. Therefore, the result does not, by any means, represent the industry in general.

Question 2: For how long have you been using your MIS or ERP system?

Those who responded that they use an MIS/ERP in Question 1 were automatically transferred to Question 2. This question was not presented to the respondents not using an MIS/ERP system. Figure 3 shows the responses for Question 2.

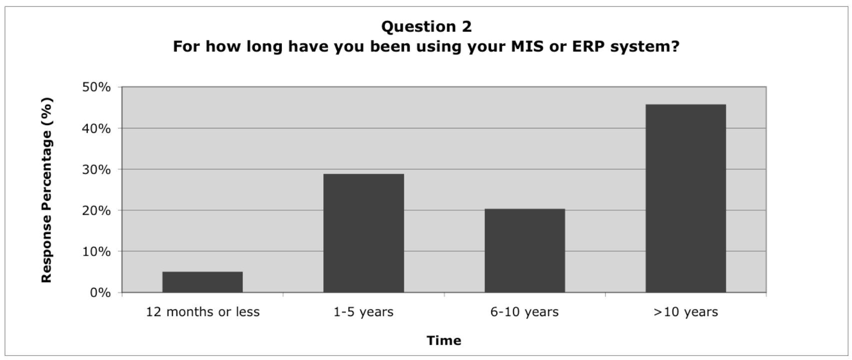


Figure 3. For how long have you been using your MIS or ERP system?

Among the respondents who use an MIS/ERP, 27 (45.8%) have been using their system for more than 10 years. Twelve (20.3%) have been using it for 6 to 10 years and 16 of the respondents (27.1%) for 1 to 5 years. Three of the respondents (5.1%) have used their MIS/ERP for 12 months or less.

Question 3: Does your company location own a scheduling module/scheduling software?

Half of the 60 respondents (50%), own and use a scheduling module or scheduling software. Fifteen (25%) answered that they do not own one and 15 (25%) own one but do not use it (Table 2).

Table 2. Does your company location own a scheduling module/scheduling software?

	Response Percent	Response Count
Yes, we own one and use it	50.0%	30
Yes, we own one but do not use it	25.0%	15
No, we do not own one	25.0%	15
Total:	100%	60

Questions 4 to 15 – Applied Skip Logic

Depending on the answer in Question 3, respondents were transferred to different sections of the survey with follow-up questions regarding their specific situation. Respondents were directed as follows:

– The response, "Yes, we own one but do not use it" directed respondents to Section 1a, Questions 4 to 7.

– The response, "Yes, we own one and use it" directed respondents to Section 1b, Questions 8 to 12.

– The response, "No, we do not own one" directed respondents to Section 1c, Questions 13 to 15.

Section 1a: Respondents Who Own, But Do Not Use, Scheduling Software

The respondents who answered, “Yes, we own scheduling software but do not use it” in Question 3 were directed to Section 1a of the survey, containing Questions 4 to 7.

<u>Question 4: Is your scheduling module/software . . . ?</u>

The majority, 11 (73.3%), of the responding companies that own a scheduling module/software but do not use it answered that it is built into their print-specific MIS. Two of the respondents (13.3%) have a home-grown scheduling system, 1 (6.7%) has a module that is built into a generic MIS/ERP, and 1 (6.7%) owns stand-alone software purchased from a vendor (Table 3).

Table 3. Is your scheduling module/software . . .

	Response Percent	Response Count
Built into a print-specific MIS	73.3%	11
Home-grown	13.3%	2
Built into a generic MIS/ERP	6.7%	1
Stand-alone software from a vendor	6.7%	1
Total:	100%	15

This question gave the respondents an opportunity to comment on their response. Two of the comments received indicated that the company locations are in the planning phase of implementing their scheduling module. Another respondent claimed that the built-in scheduling module is too time intensive and does not suit her or his small shop. The respondent is fully satisfied with a homegrown solution because it “meets all of our needs and allows tremendous flexibility fast.”

Question 5: We do not use our scheduling software because it is . . .

Table 4 shows the result from Question 5 in which the respondents rated how strongly they agreed or disagreed with 16 statements regarding their choice to not use the scheduling module they own. The answer options are arranged in descending order, with the statement that had the strongest agreement first and the one with the strongest disagreement last according to the rating average in Table 4.

Table 4. Please rate how strongly you agree or disagree with the following statements. We do not use our scheduling software because it is . . .

Answer Option	Strongly Agree (4)	Somewhat Agree (3)	Somewhat Disagree (2)	Strongly Disagree (1)	Rating Average	Response Count
Achieve better control with manual scheduling	61.5%	23.1%	15.4%	0.0%	**3.46**	13
Difficult to integrate with our workflow	57.1%	21.4%	21.4%	0.0%	**3.36**	14
Inflexible	42.9%	35.7%	14.3%	7.1%	**3.14**	14
Would not improve our profitability	53.8%	15.4%	15.4%	15.4%	**3.08**	13
Requires too much input data	35.7%	35.7%	21.4%	7.1%	**3.00**	14
Cannot handle our unique press characteristics	28.6%	42.9%	28.6%	0.0%	**3.00**	14
Requires an organizational change that we are not willing to do right now	42.9%	21.4%	21.4%	14.3%	**2.93**	14
Difficult to use	28.6%	42.9%	21.4%	7.1%	**2.93**	14
Difficult to learn	14.3%	64.3%	14.3%	7.1%	**2.86**	14
Slow	14.3%	35.7%	35.7%	14.3%	**2.50**	14
Not necessary for our business	14.3%	35.7%	35.7%	14.3%	**2.50**	14
Current estimating procedures do not support the scheduling software	7.1%	35.7%	28.6%	28.6%	**2.21**	14
Too costly to implement	14.3%	14.3%	35.7%	35.7%	**2.07**	14
Do not have a shop floor data collection system	14.3%	14.3%	21.4%	50.0%	**1.93**	14
Difficult to integrate with our MIS/ERP	7.1%	7.1%	57.1%	28.6%	**1.93**	14
Are missing necessary supportive technology	0.0%	23.1%	46.2%	30.8%	**1.92**	13

The four strongest contributing factors as to why the companies are not using their scheduling software even if they own one are as follows (in order with the most important first):

1) The belief that they can achieve better control with manual scheduling.
2) The belief that the scheduling module/software is difficult to integrate with their workflow.
3) The belief that their scheduling module/software is inflexible.
4) The belief that it would not improve the company's profitability.

Moreover, the respondents rated the factors "too costly to implement," "do not have a shop floor data collection system," "difficult to integrate with our MIS/ERP," and "are missing necessary supportive technology" as the least important contributors for not using their scheduling software.

This question had a comment field in which the respondent was given the opportunity to leave a comment. One respondent, using a generic ERP system, claimed that the "scheduling is impossible." Other factors mentioned in the comment field that contribute to not using the scheduling module/software are: too time intensive, no productivity benefit, management deficit, and lack of time to do a good evaluation of the product.

Question 6: Do you have plans to start using your scheduling software within . . . ?

The majority of the respondents, 9 (60.0%), have no plans to start using their scheduling software, while 3 (20.0%) plan to start using it within 6 months, 1 (6.7%) within 1 year, and 2 (13.3%) within 5 years (Table 5).

Table 5. Do you have plans to start using your scheduling software within . . . ?

	Response Percent	Response Count
No, no plans	60.0%	9
. . . 6 months	20.0%	3
. . . 1 year	6.7%	1
. . . 5 years	13.3%	2
Total:	100%	15

Question 7: What is your motivation to start using your scheduling software?

Question 7, "What is your motivation to start using your scheduling software?" was an open-ended follow-up question for those who answered that they have future plans to start use their scheduling software in Question 6. The answers are as follow:

- "Growing company"
- "Need for instant access and ability to modify schedules based on client requirements which change constantly"
- "Need for a more structured way to keep up with scheduling"
- "Need to communicate schedules to other plants"
- "Because it is included in the print-specific ERP"

- “Because our scheduling module is dynamic”
- “We like the ‘scenario building’ capability of the automated system”
- “To improve our overall plant productivity in all departments”
- “To try to tie all shop floor information into one system”
- “To have real time up dates of schedules”
- “Re-development of the current homegrown solution to fit the specific need of the plant. (Need something simple and flexible.)”

Section 1b: Respondents Who Own and Use Scheduling Software

The respondents who answered, “Yes, we own scheduling software and use it” in Question 3 were directed to Section 1b of the survey, containing Questions 8 to 12.

<u>Question 8: For how long have you been using your scheduling module/software?</u>

Only 1 (4.0%) company location has been using its software for less that 1 year. The majority, 15 respondents (60.0%), have been using their software for 1 to 5 years. Six of the respondents (24.0%) have been using it for 6 to 10 years and only 3 respondents (12.0%) have been using it for more than 10 years (Figure 4).

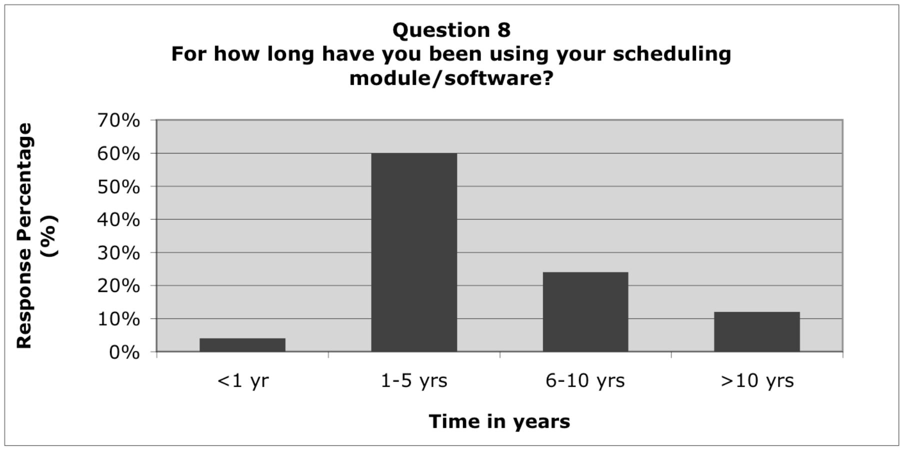


Figure 4. For how long have you been using your scheduling module/software?

Question 9: Is your scheduling module/software . . . ?

Twenty-two (75.9%) of the respondents who own and use their scheduling module/software have a system that is built into an MIS or ERP system. In 16 (55.2%) of the cases, it is built into their print-specific MIS, while 6 (20.7%) of the respondents have a scheduling system that is built into a generic MIS/ERP. Five (17.2%) of the respondents use a home-grown scheduling system and 2 (6.9%) have stand-alone software purchased from a vendor (Table 6).

Table 6. Is your scheduling module/software . . . ?

	Response Percent	Response Count
Built into a print-specific MIS	55.2%	16
Built into a generic MIS/ERP	20.7%	6
Home-grown	17.2%	5
Stand-alone software from a vendor	6.9%	2
Total:	100%	29

Question 10: What operations in your company location are planned and scheduled through the scheduling software?

All thirty respondents (100%) stated that their scheduling software is used for scheduling their printing presses. The second most common operation to schedule through the software is the bindery, which is scheduled by 28 respondents (93.3%). The prepress and distribution operations are scheduled through the software by 22 respondents (73.3%) each (Figure 5).

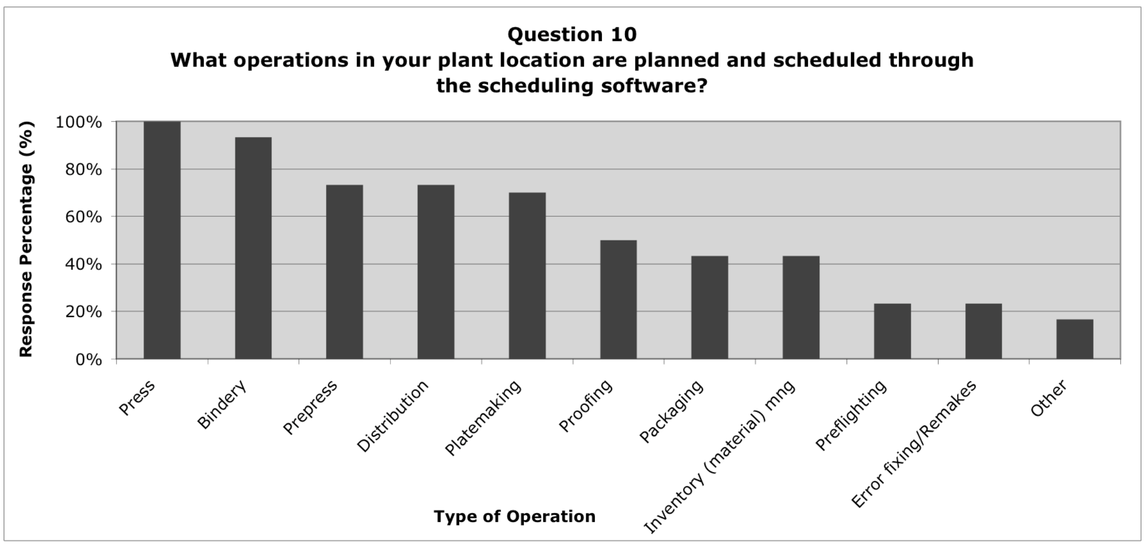


Figure 5. What operation in your plant location are planned and scheduled through the scheduling software?

The operations least commonly scheduled through the software are the preflighting and error fixing/remakes operations, which are scheduled by 7 respondents (23.3%) each. The following operations were mentioned under the "other" category: mailing (3), fulfillment (1), outsourced production (1), and staff/crew allocation (1).

Question 11: We have gained the following benefits through our scheduling module/software . . .

Table 7 shows how strongly the respondents agree or disagree with 18 potential benefits that could be gained through their scheduling software. The table is arranged in descending order with the benefits that have the strongest agreement placed first according to the Rating Average in Table 7.

Table 7. Please rate how strongly you agree or disagree with the following statements. We have gained the following benefits from using our scheduling module/software:

Answer Option	Strongly Agree (4)	Somewhat Agree (3)	Somewhat Disagree (2)	Strongly Disagree (1)	Rating Average	Response Count
Improved decision making process	73.3%	26.7%	0.0%	0.0%	**3.73**	30
More organized workflow	73.3%	26.7%	0.0%	0.0%	**3.73**	30
Improved control of production	66.7%	33.3%	0.0%	0.0%	**3.67**	30
Reduced idle time on press	60.0%	36.7%	3.3%	0.0%	**3.57**	30
Reduced overtime	60.0%	30.0%	10.0%	0.0%	**3.50**	30
Increased press productivity	56.7%	36.7%	6.7%	0.0%	**3.50**	30
Reduced idle time on bindery equipment	53.3%	43.3%	3.3%	0.0%	**3.50**	30
Increased bindery productivity	56.7%	33.3%	10.0%	0.0%	**3.47**	30
Increased rate of on-time deliveries	53.3%	40.0%	6.7%	0.0%	**3.47**	30
Increased profit	46.7%	50.0%	3.3%	0.0%	**3.43**	30
Reduced costs	40.0%	53.3%	6.7%	0.0%	**3.33**	30
Increased prepress productivity	41.4%	37.9%	20.7%	0.0%	**3.21**	29
Increased throughput time	50.0%	30.0%	6.7%	13.3%	**3.17**	30
Reduced stress level for employees	33.3%	46.7%	13.3%	6.7%	**3.07**	30
Reduced idle time on platemaking equipment	17.2%	55.2%	24.1%	3.4%	**2.86**	29
Reduced paper waste	24.1%	37.9%	34.5%	3.4%	**2.83**	29
Reduced need for human judgment	24.1%	31.0%	31.0%	13.8%	**2.66**	29
Reduced need for production meetings	20.0%	30.0%	26.7%	23.3%	**2.47**	30

The three highest rated benefits gained with the scheduling software are:

1) Improved decision making process

2) More organized workflow

3) Improved control of production

None of the responding companies claimed not to have gained these potential benefits. Moreover, nearly all of the respondents agreed that they had reduced the idle time on press (96.7%) and bindery equipment (96.6%) (in contrast with “reduced idle time on platemaking equipment,” which had a low rate of agreement), and reduced overtime by using the scheduling software. The light gray shaded area in Table 7 highlights the factors that had no disagreement from the respondents.

The potential benefits that received the weakest agreement are “reduced need for production meetings” (the highest rate of disagreement), “reduced need for human judgment,” and “reduced paper waste.” However, the companies’ answers were more diverse regarding these benefits, and some agreed strongly while some disagreed strongly. Moreover, more than 50% of the respondents somewhat or strongly agreed with these statements.

This question also provided an “other” check-box option, in which the respondent could specify a benefit not mentioned in the list. Other benefits specified are: cost savings in material purchasing through facilitation of JIT manufacturing, mitigation of WIP levels, and smoothing of production flows.

Comment. One of the benefits listed in Question 11, “increased throughput time,” was ambiguously formulated. The intended meaning of the term was “increased throughput speed” (i.e., the scheduling software has contributed to shortening the time from order to delivered product). To be clear, the term should have been “decreased throughput time.” One of the respondents made a comment about this. The researcher believes that those respondents who strongly agreed with the term read it as “decreased throughput time” (as it was intended), which is a benefit for a company, and that those who strongly disagreed, disagreed that the scheduling software has *increased* their throughput time and strongly agree that it has *decreased* their throughput time. In that case, the rating average for this factor would be 3.57, which would place the benefit in the fourth place (together with “reduced idle time on press”).

<u>Question 12: What disadvantages have you experienced with your scheduling software?</u>

The disadvantage most often checked was “high learning curve,” which was claimed by 13 (46.4%) of the respondents. Two of those respondents checked “high learning curve” as the only negative experience with the software. Ten (35.5%) respondents feel that their scheduling software requires too much updating and input data. The disadvantages “difficult implementation process” and “needs too much complementary human judgment” were each experienced by 9 (32.1%) of the respondents.

Only one company (3.6%) claimed that the scheduling module has not improved its profitability. Two (7.1%) respondents agreed that “input errors are common” and 3 (10.7%) respondents agreed with the disadvantage that the scheduling software is “expensive to implement” (Figure 6).

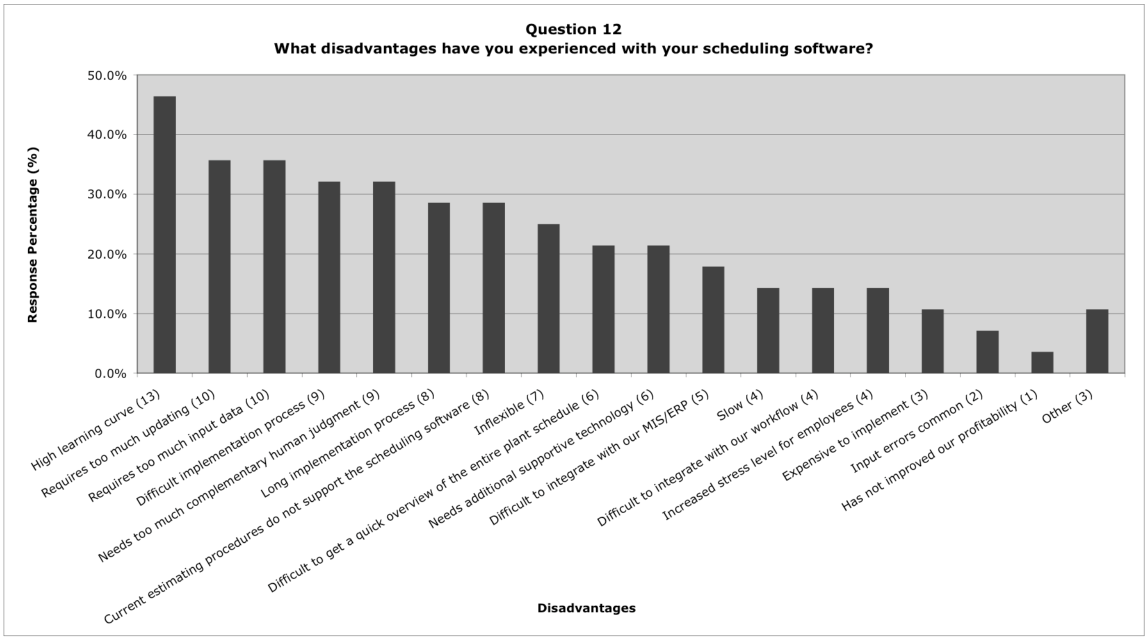


Figure 6. What disadvantages have you experienced with your scheduling software?

The respondents had the opportunity to specify additional disadvantages experienced with their scheduling software. Specified as “other” were: “cumbersome to operate,” “somewhat efficient,” and ”difficult to understand functions such as overlap production and multiple equipment operation within same production of a unit.”

One of the responding companies refused to claim any disadvantages and expressed in the comment field that its scheduling module is “FANTASTIC.”

Section 1c: Respondents Who Do Not Own Scheduling Software

The respondents who answered, “No, we do not own scheduling software” in Question 3 were directed to Section 1c of the survey, containing Questions 13 to 15:

<u>Question 13: We have not purchased scheduling software because it is . . .</u>

The two major reasons for not purchasing scheduling software are the belief that these systems are inflexible and the belief that they are difficult to implement. Furthermore, the respondents stated that it is difficult to find a solution that seems to fit their situation and they believe that they can control the scheduling function better without it.

Constraints such as “Current estimating procedures do not support the scheduling software” and “Requires an organizational change that we are not willing to do right now” have the lowest impact on the decision not to purchase scheduling software (Table 8).

Table 8. Please rate how strongly you agree or disagree with the following statements. We have not purchased scheduling software because it is . . .

Answer Option	Strongly Agree (4)	Somewhat Agree (3)	Somewhat Disagree (2)	Strongly Disagree (1)	Rating Average	Response Count
Inflexible	35.7%	50.0%	0.0%	14.3%	**3.07**	14
Difficult to implement	21.4%	57.1%	14.3%	7.1%	**2.93**	14
Have not found the right solution	28.6%	28.6%	28.6%	14.3%	**2.71**	14
Can control the scheduling function better without it	21.4%	50.0%	7.1%	21.4%	**2.71**	14
Difficult to integrate with our workflow	15.4%	46.2%	30.8%	7.7%	**2.69**	13
Difficult to use	21.4%	35.7%	28.6%	14.3%	**2.64**	14
Have not found a vendor we would like to work with	21.4%	28.6%	35.7%	14.3%	**2.57**	14
Would not improve our profitability	14.3%	21.4%	42.9%	21.4%	**2.29**	14
Difficult to integrate with our MIS/ERP	7.7%	38.5%	23.1%	30.8%	**2.23**	13
Too slow	14.3%	21.4%	35.7%	28.6%	**2.21**	14
Requires too much input data	14.3%	21.4%	35.7%	28.6%	**2.21**	14
Difficult to learn	7.1%	28.6%	35.7%	28.6%	**2.14**	14
Not necessary for our business	14.3%	7.1%	42.9%	35.7%	**2.00**	14
Cannot handle our unique press characteristics	7.1%	21.4%	35.7%	35.7%	**2.00**	14
Too expensive	7.1%	7.1%	64.3%	21.4%	**2.00**	14
Are missing necessary supportive technology	7.1%	14.3%	42.9%	35.7%	**1.93**	14
Do not have a shop floor data collection system	21.4%	7.1%	0.0%	71.4%	**1.79**	14
Requires an organizational change that we are not willing to do right now	0.0%	21.4%	28.6%	50.0%	**1.71**	14
Current estimating procedures do not support the scheduling software	0.0%	7.1%	57.1%	35.7%	**1.71**	14

The respondents were given the opportunity to add constraints that were not included in the list or to add a comment. One company claimed, “it just doesn’t work here,” because of their fast turnaround time of 3 to 5 days. Two other companies expressed their lack of need for another system because they have developed their own home-grown solutions that are “very successful” and “good enough to market.”

Question 14: Do you have plans to purchase scheduling software within . . . ?

The great majority, 14 respondents (93.3%), has no plans at all to purchase scheduling software. Only 1 respondent (6.7%) intends to purchase scheduling software within 1 year (Table 9).

Table 9. Do you have plans to purchase scheduling software within . . . ?

	Response Percent	Response Count
No, no plans	93.3%	14
. . . 6 months	0.0%	0
. . . 1 year	6.7%	1
. . . 5 years	0.0%	0
Total:	100%	15

Question 15: What is your motivation to purchase scheduling software?

Question 15 was a follow-up, open-ended question for those who responded that they have plans to purchase scheduling software in Question 14. Only 1 respondent has plans to purchase scheduling software and the reason is to increase predictability, lower costs, and increase efficiency.

Part 2

Part 2 of the survey included Questions 16 to 23 and was addressed to all the respondents.

Question 16: What is your company location's average time from receiving an order to when the finished product leaves the plant?

The majority, 45 (81.8%) of the 55 respondents, take 2 to 8 days from receiving an order to the time the finished product leaves the plant. Thirty-two of these (58.2% of the total) have a turnaround time of 5 to 8 days. One respondent (1.8%) claims to have an average turnaround time of 1 day or less (Figure 7).

Figure 7. What is your company location's average time from receiving an order to when the finished product leaves the plant?

Question 16 gave the respondents a chance to comment on their response. The comments indicate that the respondents had difficulties in calculating an average. In some cases, the order is placed a long time in advance, but as soon as the file is received, the average lead time is a few days. Two respondents claimed that the turnaround time is highly dependent on the size of the job. One respondent indicated that jobs printed on digital presses take half as long as offset printed products take from the receipt of an order to delivery of the product.

Question 17: What percentages of the jobs are delivered after the delivery date on the order specification?

Twenty-nine of the 55 respondents (52.7%) claimed that less than 2% of the jobs are delivered after the delivery date. Thirteen (23.6%) deliver 3% to 5% of the jobs after the delivery date. Three of the respondents (5.5%) have a late delivery on more than 15% of their jobs (Figure 8).

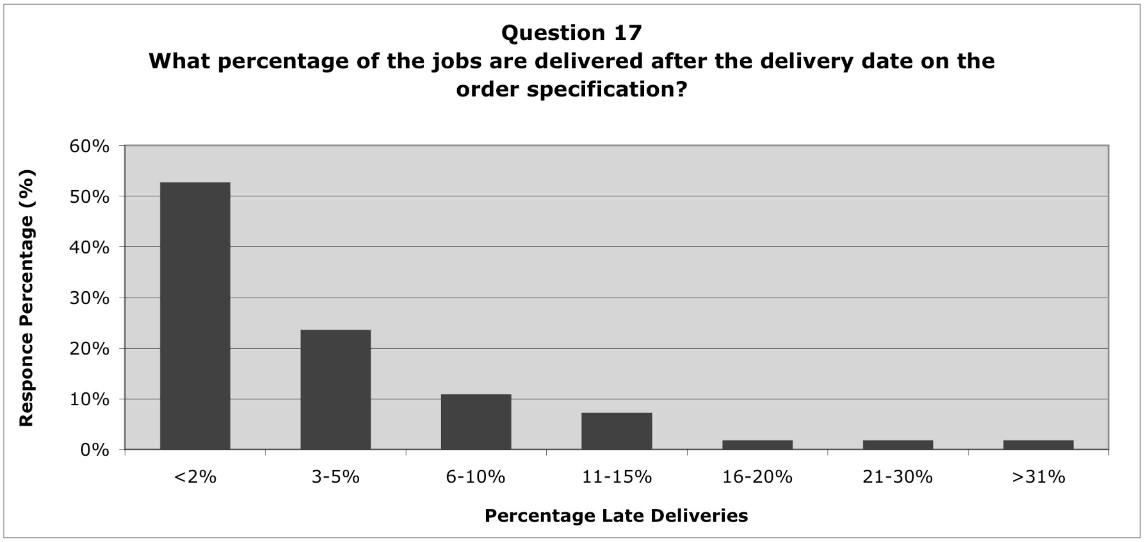


Figure 8. What percentages of the jobs are delivered after the delivery date on the order specification?

This question had an open field in which the respondent had the opportunity to leave a comment. Two respondents emphasized that they never miss due dates. Three other respondents claimed that customers who send late files, hold proofs, and make additional changes late in the process are the cause of the delays.

<u>Question 18: On average, what is the utilization rate of the equipment in the following areas?</u>

In Question 18 the respondents were asked about the utilization rate of the equipment in 10 different areas. Utilization rate was defined in the question as “the percentage of time during a shift that the equipment is operating.” The result is presented in Figures 10 to 12 in three different graphs representing the prepress, press, and postpress departments. The equipment usually found in the prepress department is shown in Figure 9. Figure 10 shows the results for the printing presses, and Figure 11 presents the equipment usually found in the postpress department. The respondents had an option to answer N/A (not applicable). This answer is not included in the results.

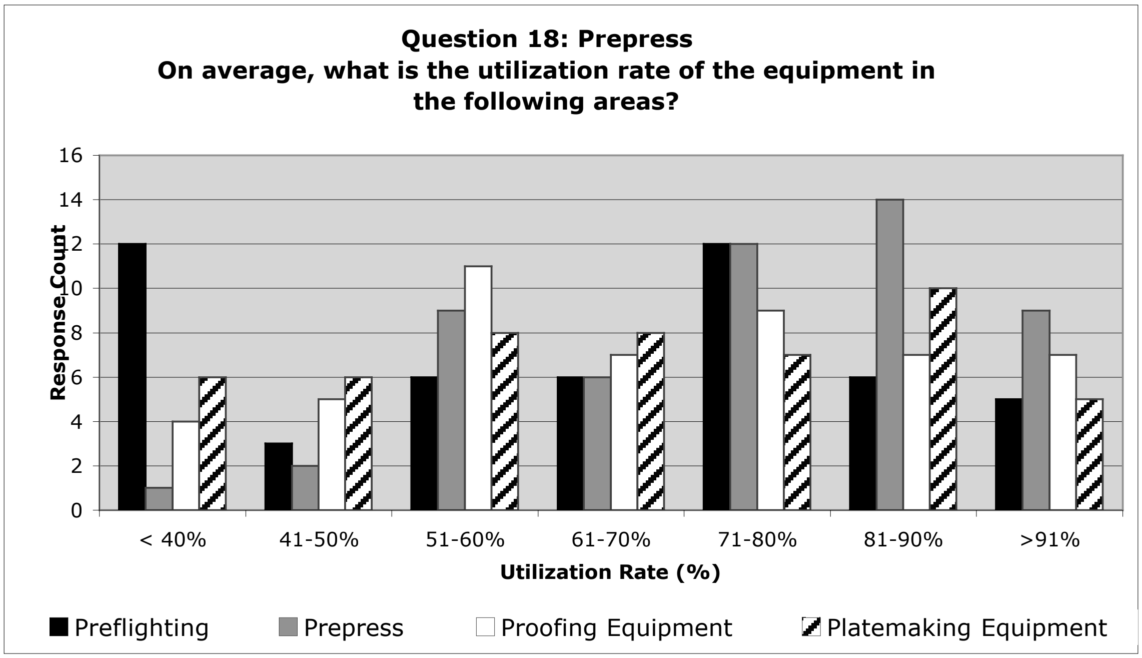


Figure 9. Prepress: On average, what is the utilization rate of the equipment in the following areas?

Twelve of the respondents (24.0%) utilize their *preflighting equipment* less than 40% of the time during a shift. The same number of respondents, 12 (24.0%), utilizes it 71% to 80% of the time. Five of the respondents (10.0%) have a high utilization rate of more that 90%.

The majority has a high utilization rate of their *prepress equipment*. Twelve of the respondents (22.6%) have a utilization rate of 71% to 80%, 14 (26.4%) utilize the equipment 81% to 90% of a shift, and 9 (17.0%) claimed to have a utilization rate of above 90%. Only 1 respondent (1.9%) utilizes it less than 40% of a shift.

The utilization rate of the *proofing equipment* is more evenly distributed compared to the other areas. Eleven respondents (22.0%) utilize the equipment at a rate of 51% to 60%. Each of the utilization rate categories 61% to 70%, 81% to 90%, and above 90% has 7 respondents (14.0%). Four respondents (8.0%) utilize their proofing equipment less than 40% of a shift.

The *platemaking equipment* is utilized at rate of 81% to 90% by 10 of the respondents (20.0%). Five respondents (10.0%) utilize it more than 90% of a shift, and 12 respondents (24.0%) have a utilization rate of less than 50%.

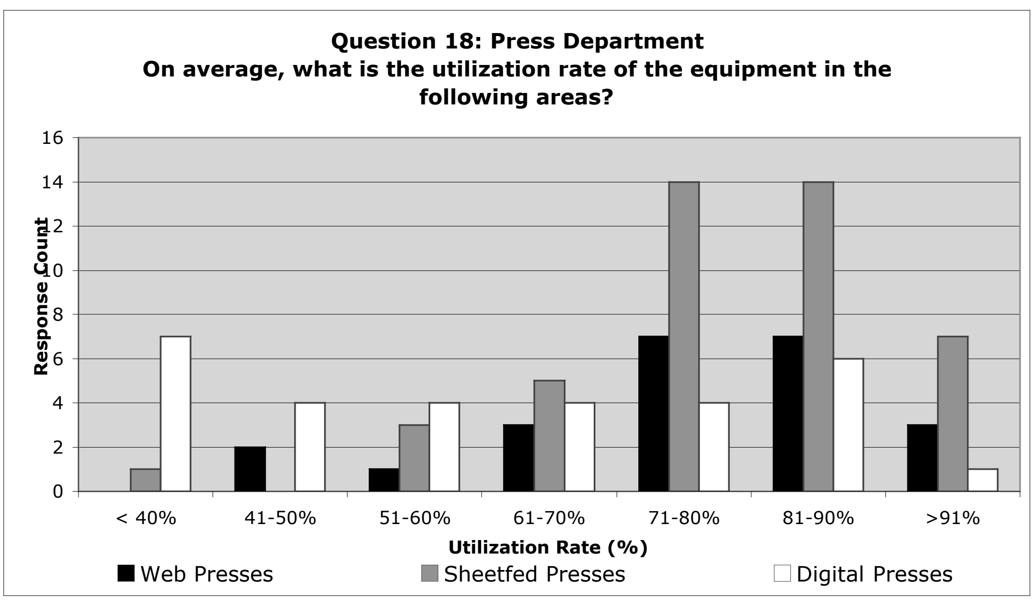


Figure 10. Press department: On average, what is the utilization rate of the equipment in the following areas?

The *web presses* at 14 of the respondents' (60.9%) printing plants are utilized 71% to 90% of the time during a shift. Three respondents (13.0%) utilize the presses more 90% of a shift. Three respondents (13.0%) have a utilization rate that is 60% or below.

The distribution of utilization rates for the *sheetfed printing presses* among the responding companies is very similar to that of the rates for the web presses. However, a larger number of respondents have sheetfed presses compared to web and digital presses. The majority, 28 of the respondents (63.6%), have a utilization rate from 71% to 90%. Only 1 respondent (2.3%) claimed to have a utilization rate below 40%. Seven respondents (15.9%) utilize their sheetfed presses over 90% of a shift.

Seven respondents (23.3%) have a utilization rate lower than 40% on the *digital printing presses*, and 6 respondents (20.0%) utilize them at a rate of 81% to 90%. In the utilization rate interval 41% to 80%, the total of 16 (53.3%) responses are evenly distributed, with 4 (13.3%) in each of the four included intervals.

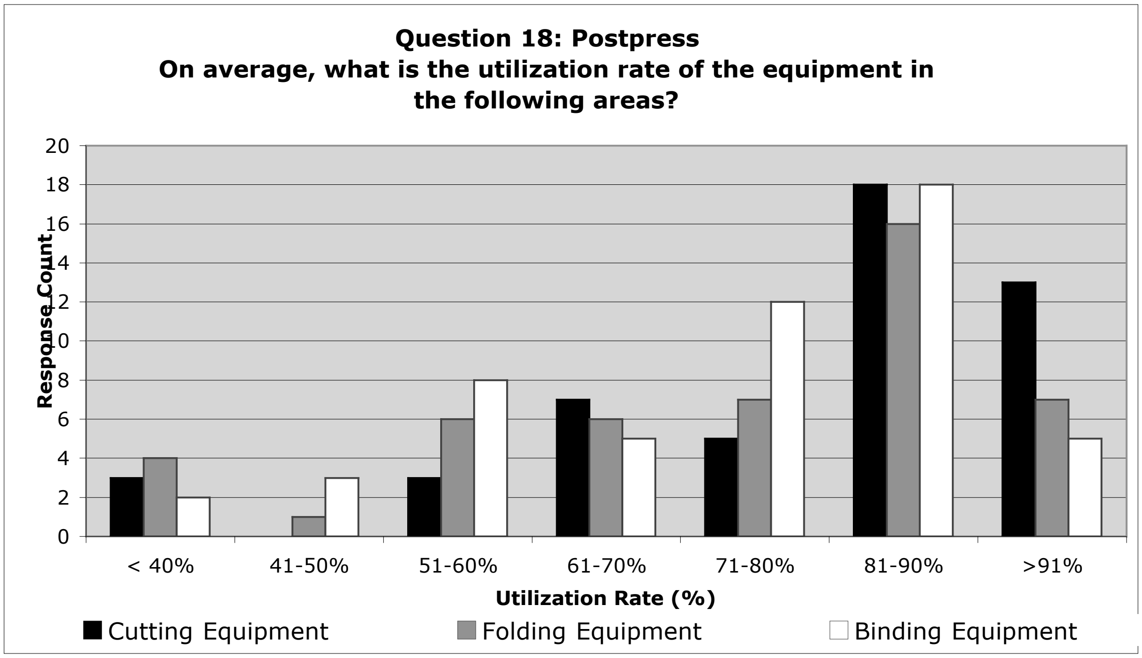


Figure 11. Postpress: On average, what is the utilization rate of the equipment in the following areas?

The *cutting equipment* has a high utilization rate. Of the respondents, 31 (63.3%) utilize the equipment at a rate of 81% or above. Three respondents (6.1%) utilize it less than 40% of the time.

The *folding equipment* is utilized over 80% of the time by 23 respondents (48.9%). Five respondents (10.6%) have a utilization rate of 50% or less.

On the *binding equipment*, 21of the respondents (39.6%) have a utilization rate of 81% or higher. Twelve respondents (22.6%) claimed to utilize the equipment 71% to 80%, while 5 respondents (9.4%) have a utilization rate of 50% or lower.

Question 19: How often do you have production meetings?

Forty-nine of the respondents (89.1%) have production meetings once a day or more often. The majority of those, 33 respondents (60.0%), have production meetings once a day. Two respondents (3.6%) have production meetings 2 to 3 times a week and the same number of respondents have them only once a week. Two respondents (3.6%) claimed that they never have production meetings (Figure 12).

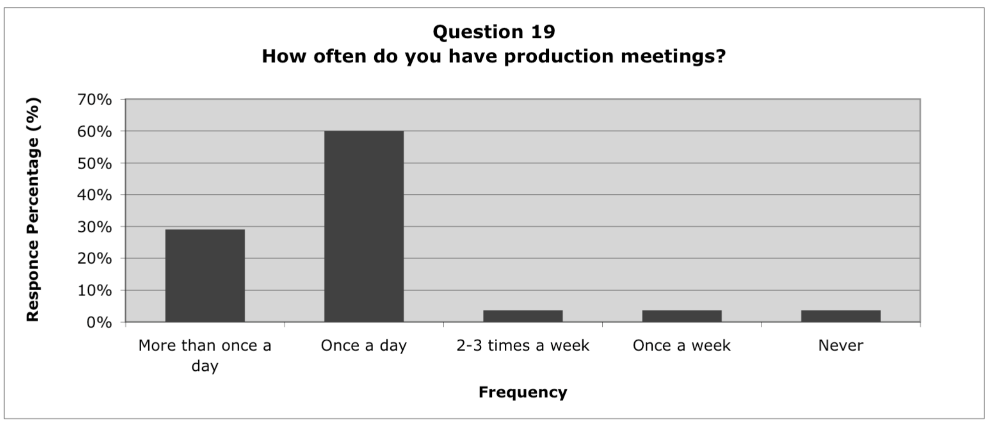


Figure 12. How often do you have production meetings?

This question offered respondents the opportunity to comment on their response. All the comments received indicated that respondents who have production meetings more often than once a day usually have one meeting in the morning and another in the afternoon. One respondent explained that the first meeting is to plan the day, while the second, and if necessary the third, are for reassessments. Another respondent holds two meetings a day, one with the bindery personnel and the second for the customer service staff.

Question 20: On average, how many complete makereadies and short makereadies do you have every day, considering all your printing presses/folders?

In Question 20, the respondents were asked how many complete makereadies and how many short makereadies take place on average per day. Complete makeready was defined as "major changes of machine settings, such as for different inks, different paper (size/stock), and/or different folds." Short makeready was defined as "using same inks and machine configurations as the previous job."

The purpose of Question 20 was to investigate the percentage of short makereadies, which are more time efficient than complete makereadies. The result presented in Figure 13 shows the percentage of short makereadies of the total number of makereadies for both printing presses and folding equipment. A high proportion indicates a large number of short makereadies. A percentage of 50% means that the responding company has an equal number of short makereadies and complete makereadies (i.e., the number of short makereadies during 1 day contributes to half of the makereadies).

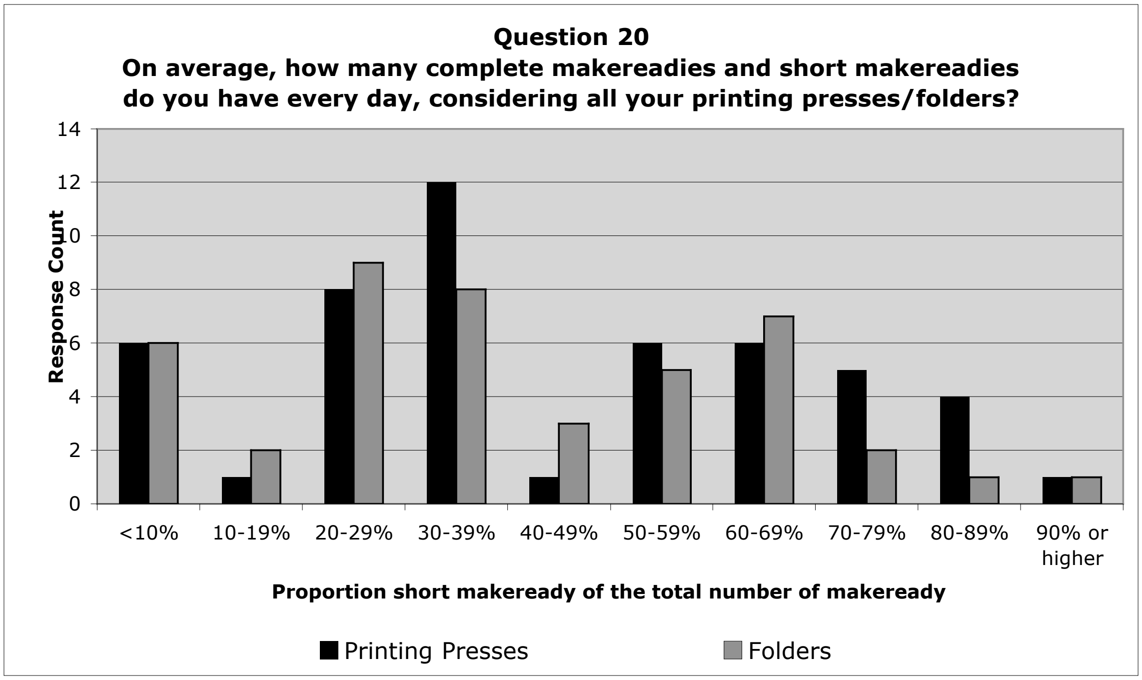


Figure 13. On average, how many complete makereadies and short makereadies do you have every day, considering all your printing presses/folders?

On the *printing presses*, 12 respondents (24.0%) have a percentage of short makereadies in the interval 30% to 39%, meaning that they have fewer short makereadies than complete makereadies. Twenty-two of the respondents (44.0%) have a percentage of short makereadies that is 50% or higher, meaning that they make as many or more short makereadies as complete makereadies.

On the *folding equipment*, 16 respondents (36.4%) have a rate of short makereadies that is 50% or higher. Seventeen of the respondents (38.6%) have a short makeready rate of 20% to 39%.

Question 21: What is the average time that a job spends between each of the following operations/functions?

Figure 14 shows the responses for Question 22, in which the respondents answered how long time a job spends between different operations and functions in the printing plant. The majority of the responses in the "2-3 days" interval are closer to 2 days.

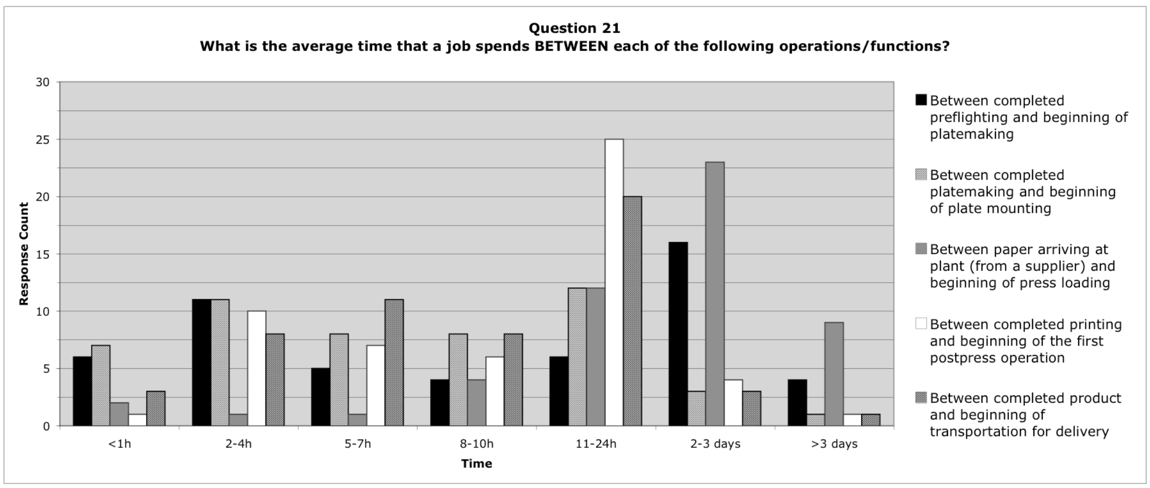


Figure 14. What is the average time that a job spends between each of the following operations/functions?

The time a job spends *between completed preflighting and beginning of platemaking* takes, for 16 of the respondents (30.8%), 2 to 3 days. Thirty-two respondents' (61.5%) companies spend 24 hour or less between the preflighting and beginning of platemaking.

The time a job spends *between completed platemaking and beginning of plate mounting* takes, for 12 of the respondents (24.0%), 11 to 24 hours. For the majority of the respondents it takes 24 hours or less. Only 4 respondents (8.0%) use more than 24 hours between completion of platemaking and mounting of the plates in the press.

For the majority, 32 of the respondents (61.5%), it takes more than 24 hours *between the time paper arrives at the plant from a supplier and the beginning of press loading*, while for 23 respondents (44.2%), it takes 2 to 3 days.

The time a job spends *between completed printing and beginning the first postpress operation* is 11 to 24 hours for 25 of the respondents (46.3%). The majority of the respondents' companies spend less than 24 hours between the two operations. Ten respondents (18.5%) claimed that their companies only spend 2 to 4 hours between the two operations.

Twenty respondents (37.0%) claimed that it takes 11 to 24 hours *between completion of the product and the beginning of transportation for delivery*. Only 4 respondents (7.4%) claimed that they use more than 24 hours between the two operations.

<u>Questions 22 and 23</u>

In Question 22, the respondents were asked to give the name of the company they represent. The reason for asking this question was to ensure that the responding companies would not receive a second email, reminding them to complete the survey.

Question 23 asked the respondents if they agree to be contacted for a follow-up interview. Thirty-three respondents agreed to be contacted again.

Chapter 6

Analysis and Summary

In this chapter, the results are analyzed and summarized in regards to the two initially stated research questions.

Research Question 1:

Why are companies that own a scheduling module/software not using it?

The scheduling function of a printing plant has a major impact on a company's profitability (Gehman, 2003; O'Brien, 2003). Lately, advanced scheduling software has been introduced to facilitate the scheduling function of a printing plant (PrintCom & Mason, 2005). It is not unusual for these scheduling applications to be built-in modules in print-specific MISs (Gehman, 2003). Two different sources indicate that about 50% to 60% of the printing plants in the commercial segment of the industry employ an MIS (Cost & Daly, 2003; PrintCom & Mason, 2005). However, the rate of printing plants using scheduling module/software is less than 15% (Goldman, 2007). People in the industry express an interest in finding the reason for the low level of usage among those companies that own the module/software.

Analysis and Discussion

Fifteen respondents (25.0%) claimed they own a scheduling module/software but do not use it. Eleven of these (73.3%) own a scheduling module/software that is built into a print-specific MIS. One owns stand-alone software and another respondent claimed to own scheduling software that is built into a generic MIS/ERP system. Two of the respondents who do not use their software have a home-grown scheduling system (Figure 15).

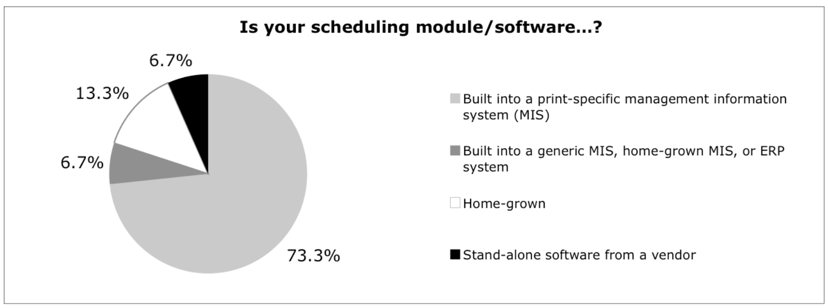


Figure 15. Is your scheduling module/software built into a print-specific MIS/ERP, a generic or home-grown MIS/ERP, a home-grown system, or stand-alone software from a vendor?

Thirteen (86.7%) of the respondents who do not use the scheduling module they own use a print-specific MIS, while the other 2 respondents (13.3%) use a generic or home-grown MIS/ERP system.

Seven (46.7%) of the 15 respondents who do not use the scheduling module that they own have used their MIS/ERP system for at least 2 years. Five respondents (33.3%) have used their MIS/ERP system for over 10 years, while 3 respondents (20.0%) have used their MIS/ERP system for 1 year or less (Figure 16). Figure 17 shows the average ratings of the 16 statements by respondents who do not use the scheduling software that they own.

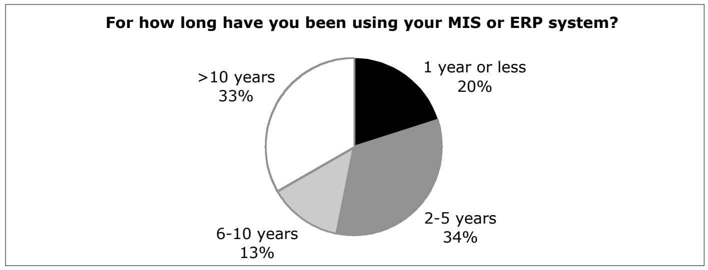


Figure 16. For how long have you been using your MIS or ERP system?

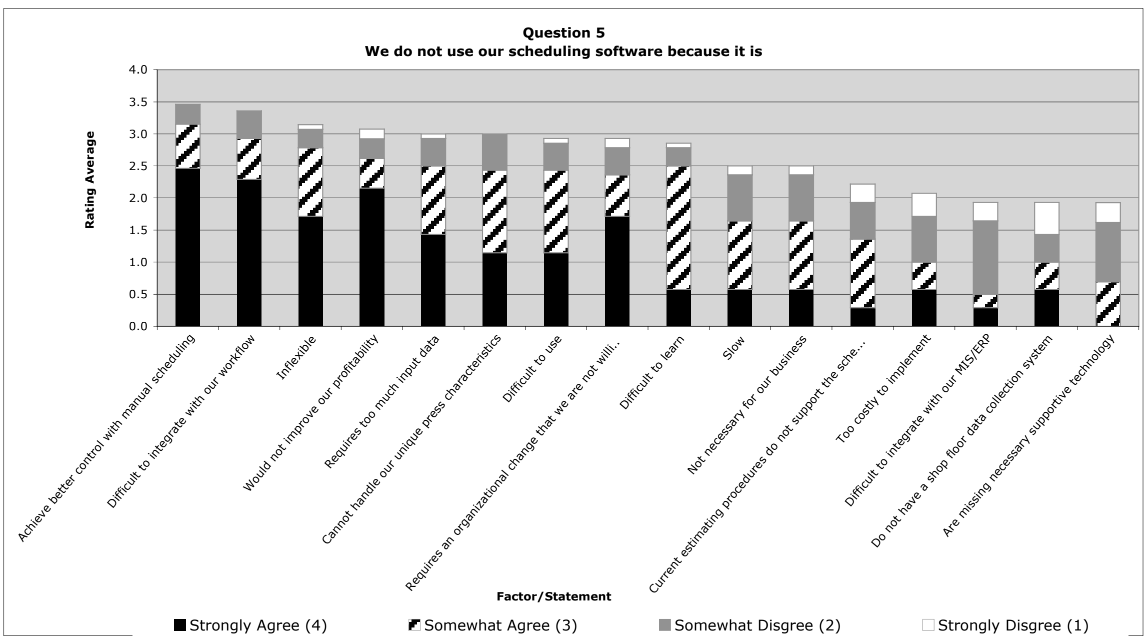


Figure 17. Please rate how strongly you agree or disagree with the following statements (4=Strongly Agree, 1=Strongly Disagree).

The following are the top four reasons why respondents who own a scheduling module/software do not use it. They are presented in descending order, with the most prevalent first:

1) They believe that they can achieve better control with manual scheduling.
2) They believe that it is difficult to integrate with their workflow.
3) They believe that it is inflexible.
4) They believe that it would not improve the company location's profitability.

The above factors are discussed briefly and compared with the opinion of respondents who are using their scheduling module/software and respondents who do not own one.

<u>Achieve Better Control With Manual Scheduling.</u> More than 70% of the companies that *do not own* scheduling software strongly agreed (21.4%) or somewhat agreed (50.0%) that this is a reason not to purchase it. However, all of the respondents who *use* their scheduling software claimed that the software has helped them to improve the control of production (66.7% strongly agreed and 33.3% somewhat agreed). Moreover, 73.3% of the *users* claimed that the software has improved their decision making process.

<u>Difficult to Integrate With the Workflow</u>. More than 60% of the respondents who *do not own* scheduling software strongly agreed (15.4%) or somewhat agreed (46.2%) that this integration issue is a reason not to purchase it. Only 4 respondents (14.3%) who *use* scheduling software have experienced difficulties in integrating the software into their workflow, but all of the 30 surveyed scheduling software *users* responded that they have

achieved a more organized workflow with their scheduling module/software (73.3% strongly agreed and 26.7% somewhat agreed).

Inflexible. More than 85% of the respondents who *do not own* scheduling software strongly agreed (35.7%) or somewhat agreed (50.0%) that this is a reason not to purchase it. Inflexibility of the scheduling system was experienced by 7 of the respondents (25.0%) who *use* scheduling software.

Would Not Improve Profitability. Among the respondents who *do not own* scheduling software, 35.7% agreed (14.3% strongly and 21.4% somewhat) that they have not purchased scheduling software because they believe it would not improve their profitability. The surveyed respondents who *use* their scheduling software indicated the opposite. Almost all of them, 96.7%, agreed that the use of scheduling software has increased their profit (46.7% strongly agreed and 50.0% somewhat agreed).

The factors with the weakest contribution to the respondents' choice not to use the scheduling module/software that they own are, in order with the weakest contributing factor (the one with the lowest rate of agreement) first:

1) They are missing necessary supportive technology.
2) They do not have a shop floor data collection system.
3) They believe it is difficult to integrate with their MIS/ERP system.

These three factors had an average rating below 2.0, where 2 equals "somewhat disagree" that the factor contributes to respondents' decision not to use it, and 1 is the lowest rating that equals "strongly disagree" that the factor contributes to their decision not to use it.

The negative factors such as integration issues with the MIS/ERP and the high cost to implement the scheduling module/software might have been rated low because the majority of the respondents own scheduling software that is built into their MISs. However, 2 respondents strongly or somewhat agreed that the difficulty of integrating with their MIS/ERP is a contributing factor to their decision not to use the scheduling software. One of these respondents has a print-specific MIS with a built-in scheduling module. Moreover, 4 respondents strongly or somewhat agreed that the high cost of implementation is a contributing factor to their choice not to use the scheduling software. Of the 2 respondents who strongly agreed, 1 has a non-print-specific MIS/ERP with built-in scheduling function, while the other's MIS and scheduling software are two separate systems.

The above ranking of factors contributing to respondents' decision not to use the scheduling software is based on the average ranking among all the respondents who own scheduling software but do not use it. The number of years a company has been using its MIS/ERP impacts its attitude to the 16 statements as well whether or not the scheduling module it owns is built into a print MIS/ERP. The following was found:

Usage of MIS/ERP for 5 Years or Fewer. The respondents who have been using their MIS/ERP system for 5 years or fewer had the highest level of strong agreement with the 16 factors contributing to their decision not to use their software. This group is most diverse in terms of the type of scheduling software they own (i.e., built into an MIS/ERP, home-grown, or stand-alone). The majority of the respondents in this group had no future plans to implement their scheduling software. A possible reason is that the companies want to get used to the other MIS functions before implementing the scheduling module.

Usage of MIS/ERP for 6 Years or More. The respondents who have been using an MIS/ERP for 6 years or more rated "requires an organizational change that we are not willing to do right now" as the leading contributing factor in their choice not to start using their scheduling software. Half of the respondents in this group had no future plans to start using their scheduling module/software.

Scheduling Software Built Into a Print-Specific MIS/ERP. The majority of the respondents in this group had no future plans to start using their scheduling module/software. Their rating of factors contributing to their decision not to use scheduling software correspond with the rating average for the whole sample. A possible reason for the respondents' opinion is that the software that comes automatically with the MIS system might be either insufficient or too complex for their need. As Gehman (2003) states, scheduling modules that are built into print-specific MISs vary from simple scheduling tools to advanced full-featured ones.

Scheduling Software not Built Into a Print-Specific MIS/ERP. The respondents who own scheduling software that is not built into a print-specific MIS/ERP rated "would not improve our profitability" and "requires too much input data" as the leading factors contributing to their decision not to start using their scheduling software. In general, this group had a higher rating average, meaning that they more often strongly agreed with the 16 factors for not using the scheduling software.

Summary of Research Question 1

Of the total number of respondents in the email survey, 15 (25.0%) do not use a scheduling module/software even though they own one. Their top reason for not using it is that they believe that they can control the scheduling function better by doing it manually. Moreover, the respondents believe integration with their current workflow would be difficult and therefore refuse to start using the scheduling software. The majority, 60%, of the respondents who own a scheduling module/software but do not use it had no future plans to start using it.

Respondents who have been using their MIS/ERP for 5 years or fewer and those who use non-print-specific MIS/ERP systems expressed the most negative attitude toward the scheduling module/software.

Research Question 2:

Are companies that are using computer-assisted scheduling different in performance on the following factors compared to those who do not use computer-assisted scheduling?

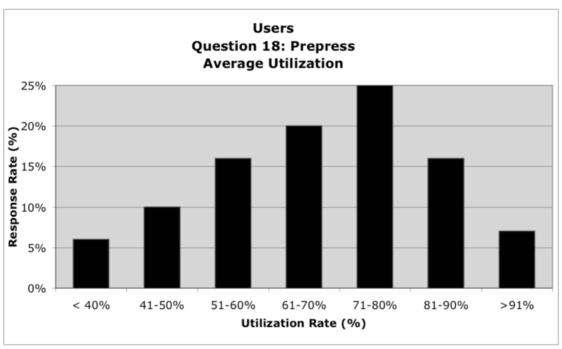
- ***Equipment utilization rate***
- ***Throughput time***
- ***The time a job spends between different operations/functions***
- ***On-time deliveries***
- ***Frequency of production meetings***
- ***Percentage of short makereadies***

The result for each area is discussed below. The purpose of Research Question 2 was to determine whether there is a difference between the companies that use computer-assisted scheduling (called *users* in the text) and these that do not (called *nonusers* in the text). The results may indicate that the usage of scheduling software impacts a company's performance. However, the differences found could also be dependent on other factors not covered in this study.

Equipment Utilization Rate

Underutilization of resources is classified as the eighth waste and complements the traditional seven wastes that a lean manufacturing initiative aims to eliminate. People as well as technology can be underutilized. In the email questionnaire, the participating companies were asked to estimate their average utilization rate of equipment in 10 areas. The results were summarized and divided into the main areas: prepress, press, and postpress. The original question as given to the respondents contained an N/A (not applicable) answering option. These responses were not included in the analysis, and were compensated for in the response percentage rate.

Prepress Department. Figure 18 shows the summary result for *users* compared with *nonusers* of scheduling software for the equipment usually located in the prepress department. Equipment included in the summary result for prepress is: preflighting, prepress, proofing, and platemaking equipment.



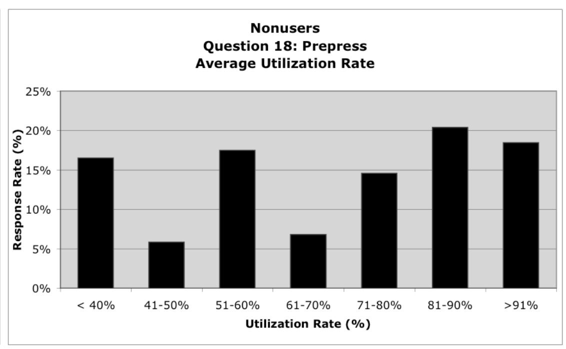


Figure 18. Utilization rate of the equipment usually located in the prepress department (users of scheduling software compared to nonusers).

Few of the responding *users* have a very low or very high utilization rate compared with the *nonusers*. The utilization rates of the *nonusers'* prepress equipment are more scattered, with a relatively high percentage of *nonusers* utilizing their equipment either at a very low rate or at a very high rate.

Table 10. The response percentage for each of the utilization rate (U R) intervals ≤ 50%, 71-90%, and > 90% for equipment usually located in the prepress department.

	≤ 50% U R	**71-90% U R**	**> 90% U R**	**Total number of responses**	**Mean U R**
Users (%)	16.0%	41.0%	7.0%	100	67%
Nonusers (%)	22.3%	49.5%	18.4%	103	66%

Table 10 indicates that a larger number of *nonusers* have a very low utilization rate (≤ 50%) or a very high utilization rate (> 90%) of their prepress equipment, compared to the *users*. The mean utilization rate for *users* is 67% and for *nonusers* is 66%. Note that the "total number of responses" includes *all* of the responses relating to the prepress department were aggregated, thus resulting in a total of 100 responses for users and 103 for nonusers.

Press Department. Figure 19 shows the differences between *users* and *nonusers* of scheduling software in utilization rates of the equipment in the press department. The following equipment is included in the press department: web presses, sheetfed presses, and digital presses. A high percentage of the respondents answered N/A, especially for web and digital presses, which most likely means that they do not own this equipment. The N/A answer category was removed from the calculations of percentage.

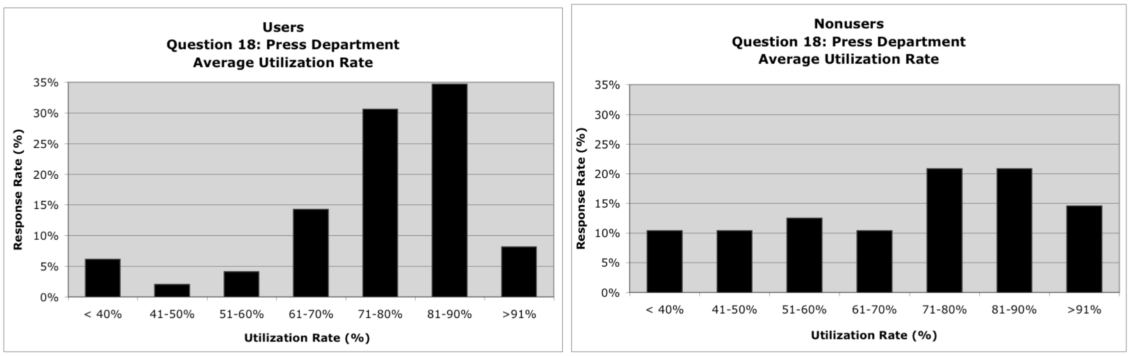


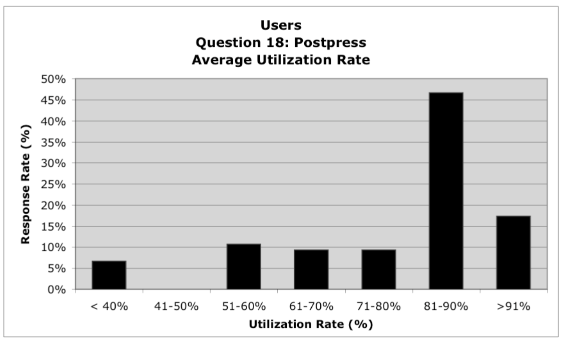
Figure 19. Utilization rate of the equipment usually located in the press department (users of computer-assisted scheduling compared to nonusers).

Both the *users* and the *nonusers* have two peaks in the 71% to 90% utilization rate interval. However, the *nonusers'* utilization rates are more evenly distributed over all the intervals. Table 11 indicates that a higher percentage of the *nonusers* have a very low utilization rate (≤ 50%), or a very high utilization rate (> 90%), compared with the *users*. However, a larger number of the *users* (65.3%) have a utilization rate in the interval 71% to 90% compared to the *nonusers* (41.7%). The mean utilization rate for *users* is 74% and for is *nonusers* 68%. Note that the "total number of responses" includes *all* of the responses relating to the press department were aggregated, thus resulting in a total of 49 responses for users and 48 for nonusers.

Table 11. The response percentage for each of the utilization rate (U R) intervals ≤ 50%, 71-90%, and > 90% for equipment usually located in the press department.

	≤ 50% U R	**71-90% U R**	**> 90% U R**	**Total number of responses**	**Mean U R**
Users (%)	8.2%	65.3%	8.2%	49	74%
Nonusers (%)	20.8%	41.7%	14.6%	48	68%

Postpress Department. Figure 20 shows the differences between *users* and *nonusers* of scheduling software in utilization rates of the equipment in the postpress department. Equipment included in the postpress department is: cutting, folding, and binding equipment.



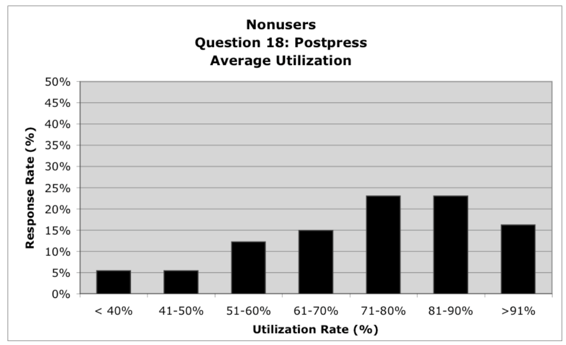


Figure 20. Average utilization rate of the equipment usually located in the postpress department (users of computer-assisted scheduling compared to nonusers).

A large number of the *users* (46.7%) have a utilization rate in the 81% to 90% interval. All the intervals below 81% have a low response rate in comparison. Among the *nonusers*, the respondents are more evenly distributed over the utilization rate intervals, with two (small) peaks at the 71% to 80% and 81% to 90% intervals.

Table 12 indicates that a larger percentage of the *nonusers* (10.8%) have a very low utilization rate (≤ 50%) compared with the *users* (6.7%). A larger group of the *users* (73.3%) have a utilization rate above 70% compared to the *nonusers* (62.2%). The mean utilization rate for *users* is 77% and for *nonusers* is 72%. Note that the “total number of responses" includes *all* of the responses relating to the postpress department were aggregated, thus resulting in a total of 75 responses for users and 74 for nonusers.

Table 12. The response percentage for each of the utilization rate (U R) intervals ≤ 50%, 71-90%, and > 90% for equipment usually located in the postpress department.

	≤ 50% U R	**71-90% U R**	**> 90% U R**	**Total number of responses**	**Mean U R**
Users (%)	6.7%	56.0%	17.3%	75	77%
Nonusers (%)	10.8%	45.9%	16.2%	74	72%

Summary. More *nonusers* than *users* have very low (≤ 50%) utilization rates in all departments (prepress, press, and postpress). Also, more *nonusers* than *users* have a very high utilization level (> 90%) of equipment in the prepress and press departments. The utilization rate mean is higher for the *users* compared with the *nonusers* in all departments. However, the difference in means for the prepress department is marginal.

Throughput Time

The speed and continuity of a printing job's throughput is an important factor that contributes to a printer's profitability (Dickeson, 2002; O'Brien, 2003). The usage of computer-assisted scheduling can reduce a job's cycle time (PrintCom & Mason, 2005). One of the five principles of lean manufacturing is to establish a flow process, with the objective of reducing inventory, such as WIP. Flow also yields faster throughput, which allows for increased output per person (Dixon, 2001b).

Figure 21 shows the respondents' average time from receiving an order to when the finished product leaves the plant, divided between *users* of scheduling software and *nonusers*. The two *users* that claimed to use more than a month in throughput time are possible outliers. One of them left a comment that indicated that the question was misunderstood and that the time the responding company uses from receiving an order to delivering the product is more likely within the interval 2-4 days. The graph to the right illustrates the result when one of the outliers is removed and the other is moved to the 2-4 day interval.

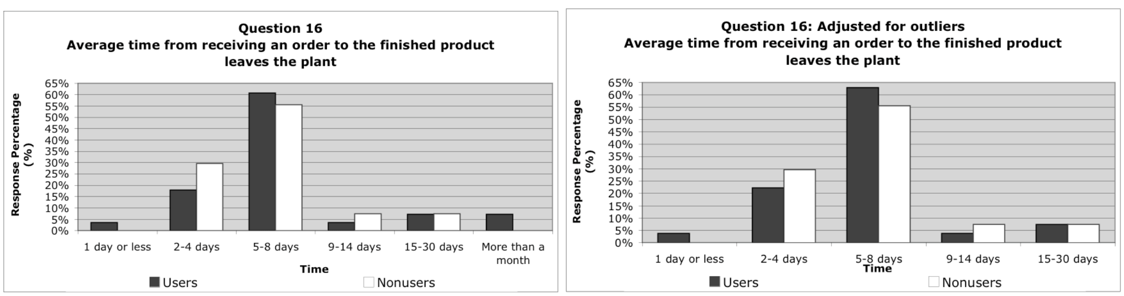


Figure 21. The difference in throughput time between users and nonusers of computer-assisted scheduling software (original result to the left, result adjusted for outliers to the right).

Original Result (left graph). The majority in both the *user* and the *nonuser* group use 5 to 8 days from receiving an order to when the finished product leaves the plant. A larger part of the *nonusers* (29.6%) use 4 days or less for the same operation compared to the *users* (21.4%). A larger part of the *users* (17.9%) use 9 days or more from receiving an order to delivering the final product compared to the *nonusers* (14.8%). The mean time from receiving an order to when the finished product leaves the plant is 9 days for the *users* of scheduling software and 7 days for the *nonusers*.

Adjusted Result (right graph). A larger percentage of *nonusers* (29.6%) use 4 days or less for the same operation compared to the *users* (25.9%). However, the gap between the two is smaller than in the original result (with outliers included). More *nonusers* (16.7%) than *users* (11.1%) fall in the interval 9 days or more, which is the opposite result from the original. In the adjusted result, the mean time from receiving an order to when the finished product leaves the plant is 7 days for both the *users* and the *nonusers* of scheduling software.

Waiting Time: The Time a Job Spends Between Two Different Operations/Functions

The time a job spends waiting *between* different operations and functions in a printing plant adds to the throughput time and adds no value to the product. From a lean manufacturing perspective, this is categorized as an inventory waste, meaning that anything of value (WIP, raw material, or finished goods) sits in the plant waiting further processing (Cooper, Keif, & Macro, 2007). Well executed scheduling allows for better resource allocation and increased throughput (Cross, 2006; O'Brien, 2003).

In Figure 22, *users* of scheduling software are compared to *nonusers* regarding the time spent between some of the operations and functions in a printing facility.

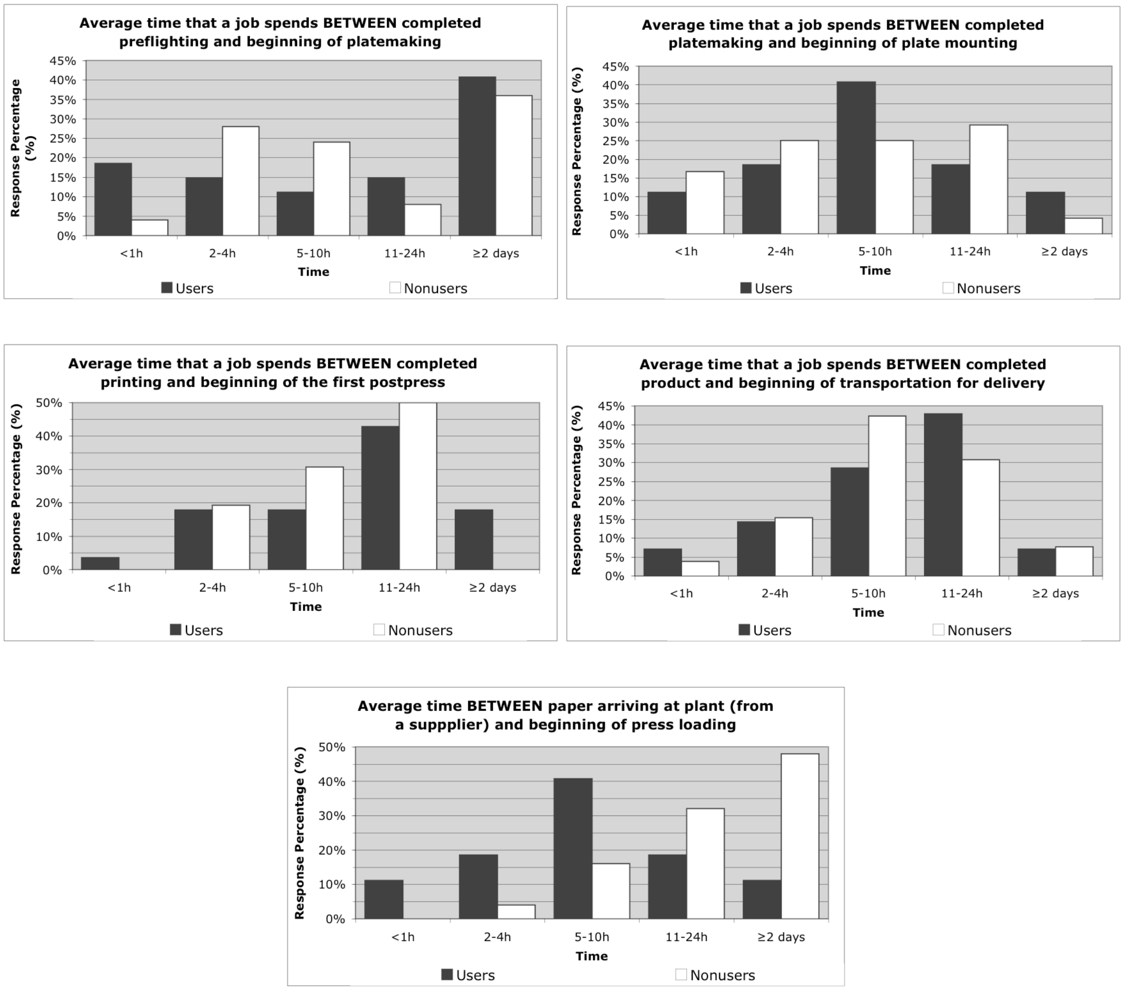


Figure 22. The time a job spends between different operations/functions in a printing plant (users of scheduling software in comparison with nonusers).

More of the *users* than the *nonusers* have their jobs waiting between two operations/functions for less than 1 hour. The exception is "between completed platemaking and beginning of plate mounting," in which a higher percentage of the *nonusers* than the *users* claimed that the jobs spends less than 1 hour waiting.

Both *users* and *nonusers* have a large number of respondents that claimed to use 2 days or more between completed preflighting and beginning of platemaking. This group of respondents might have customers who request hard proofs for approval before platemaking can start, which delays the process.

Table 13 shows the mean time a job spends waiting between two operations/functions in a printing plant for the *users* compared to the *nonusers*.

Table 13. The mean time a job spends waiting between two operations/functions (users of scheduling software compared to nonusers).

Waiting Time Between . . .	**Users**	**Nonusers**
. . . completed preflighting and beginning of platemaking	30 h	27 h
. . . completed platemaking and beginning of plate mounting	15 h	10 h
. . . completed printing and beginning of the first postpress operation	21 h	12 h
. . . completed product and beginning of transportation for delivery	14 h	14 h
. . . paper arriving at plant (from a supplier) and beginning of press loading	15 h	39 h
Sum excl. the time between paper delivery and press loading:	80 h (3.3 days)	63 h (2.6 days)

The *nonuser* group has a lower (better) mean compared to the *users* in three of the five categories investigated: between completed preflighting and beginning of platemaking, between completed platemaking and beginning of plate mounting, and between completed printing and beginning of the first postpress operation.

The greatest difference in time between *users* (15 hours) and *nonusers* (39 hours) is found in the time it takes from paper arriving at the plant from a supplier to the beginning of the loading of paper in the press. The results indicate that *users* may tend to work on a JIT basis for delivery of raw material, which is part of achieving a flow process in lean manufacturing.

The total time a job waits between operations for the next step is 80 hours (3.3 days) for the *users* of computer-assisted scheduling and 62 hours (2.6 days) for *nonusers*.

On-Time Deliveries

The number of late deliveries is an indicator of customer satisfaction from a lean manufacturing perspective. The indicator can be used when estimating a product's value according to the first of the five lean manufacturing principles (Meier, 2001a). A late delivery diverges from the specification and fails to meet the customer's requirement. Therefore, it is classified as a waste in the defects category (Dixon, 2001a). The usage of computer-assisted scheduling can help increase the number of on-time deliveries (PrintCom & Mason, 2005).

Figure 23 shows the difference in number of late deliveries between *users* and *nonusers* of scheduling software. The graph to the left shows the original result from the survey. The graph to the right shows the result adjusted for possible outliers (i.e., respondents with a late delivery rate above 15%).

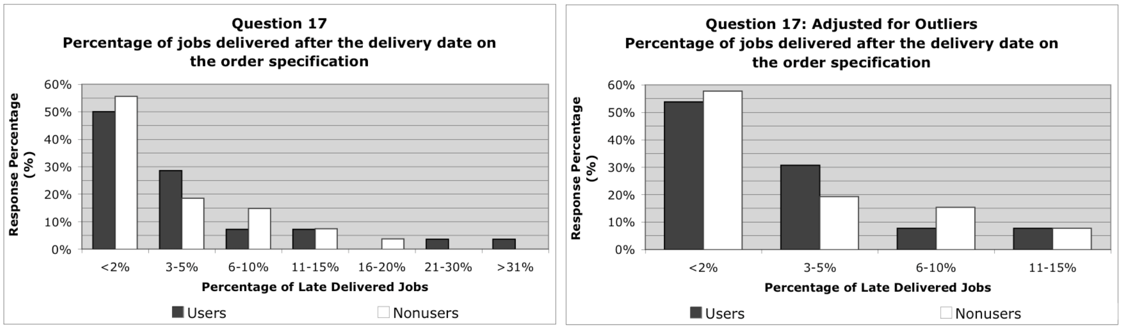


Figure 23. Percentage of jobs delivered after the date specified on the order (users of scheduling software compared to nonusers).

Original Result (left graph). A larger percentage of the *nonusers* (55.6%) have less than 2% late deliveries, compared to *users* (50.0%). A larger percentage of the *nonusers* (25.9%) have more than 5% late deliveries, compared to the *users* (21.4%). On average, the responding *users* have 5.2% late deliveries, while the *nonusers* have 4.1% late deliveries. The high average for the *user* group is strongly affected by two respondents who have a very high rate of late deliveries (> 20%).

Adjusted Result (right graph). A larger percentage of the *nonusers* (57.7%) have less than 2% late deliveries, compared to *users* (53.8%). In the more than 5% late deliveries category, the *nonusers* (23.1%) are overrepresented compared to the *users* (15.4%). On average, the responding *users* have 3.4% late deliveries, while the *nonusers* have 3.6% late deliveries.

Comment. Two of the respondents in the *user* group claimed to have 100% on-time deliveries. In the calculations of the mean, these two respondents were treated the same as the rest of the respondents in the interval < 2%.

Frequency of Production Meetings

This question was included in the study because it was found during the review of literature that one company using computer-assisted scheduling has experienced a reduced need for production meetings (Vision in Print, 2006). Production meetings do not have to be something bad that has to be eliminated. More important than the frequency is the efficiency of production meetings. Figure 24 shows the difference in frequency of production meetings between users and nonusers of scheduling software.

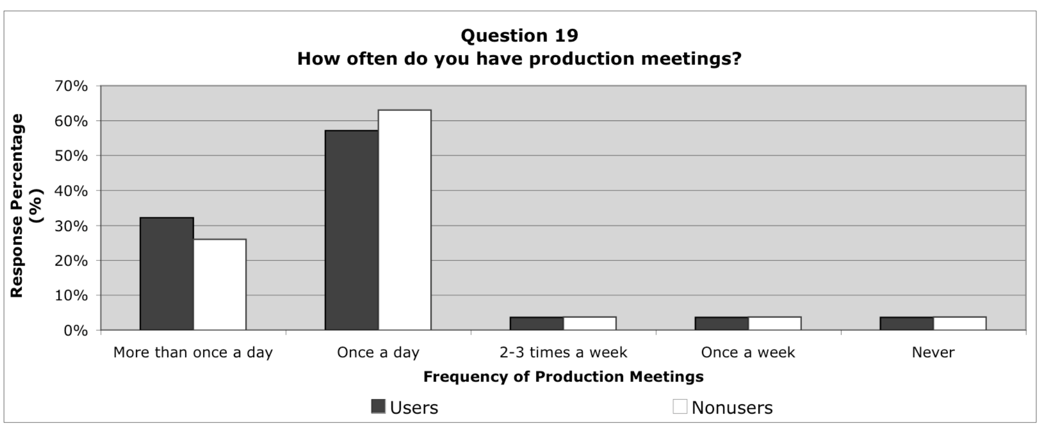


Figure 24. The difference in the number of production meetings between users of computer-assisted scheduling and nonusers.

More *users* (32.1%) than *nonusers* (25.9%) have production meetings more often than once a day. Fewer *users* (10.7%) than *nonusers* (11.1%) have production meetings two to three times a week, once a week, or never. On average, *users* have production meetings more frequently than *nonusers*. However, in both the *user* and the *nonuser* group, the majority has production meetings once a day.

Percentage of Short Makereadies

One of the tools for lean manufacturing is "quick changeover." Its objective is to reduce the time it takes to set up a machine between two jobs (Centers & West, 2001). The set-ups in a printing environment can be divided into short makeready (or switchover) and complete makeready (or just makeready). In a short makeready, the same ink and press/machine configurations are used for the next job, while a complete makeready occurs when the next job requires major changes of the machine settings.

With scheduling software, "what if" scenarios can be executed faster and easier than with manual scheduling. By trying different what if scenarios, the sequence of jobs can be scheduled so that the number of short makereadies is maximized (Gehman, 2003).

Printing Presses. Figure 25 shows the difference in percentage of short makereadies per day on the respondents' printing presses between *users* and *nonusers* of scheduling software. A higher percentage indicates a larger number of short makereadies.

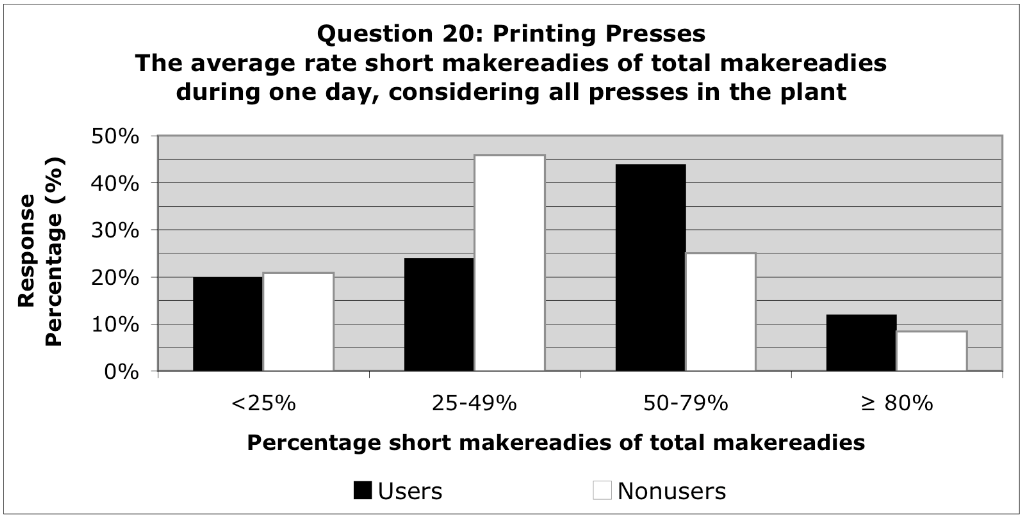


Figure 25. The difference in percentage short makereadies of the total number of makereadies (on the respondents' printing presses) between users and nonusers of scheduling software.

A larger group of the *users* (56.0%) have a short makeready proportion that is 50% or greater, compared to the *nonusers* (33.3%), on the printing presses. The mean percentage of short makereadies for the *users* is 46%, and for the *nonusers* it is 41% (50% indicates that the numbers of short and complete makereadies are equal).

Folding Equipment. Figure 26 shows the difference in proportion of short makereadies per day on the respondent's folding equipment between users and nonusers of scheduling software. A higher proportion indicates a larger number of short makereadies.

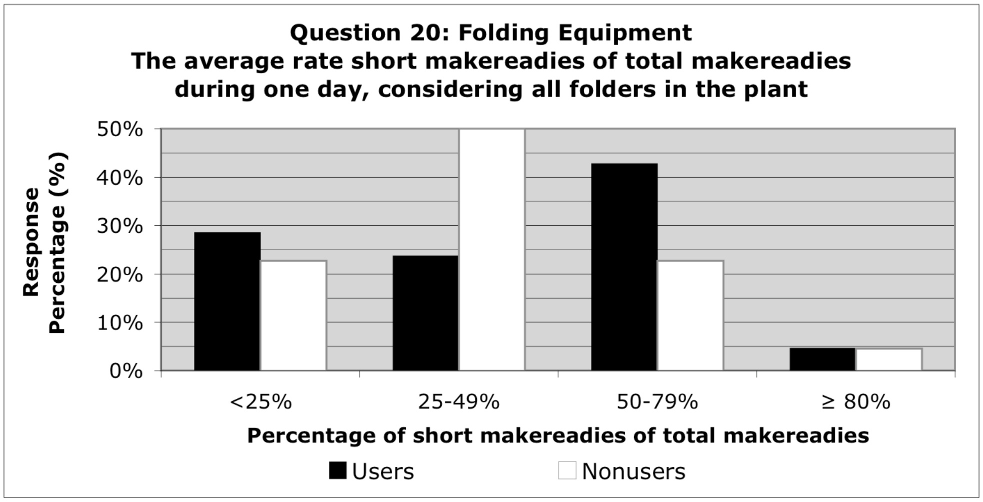


Figure 26. The difference in percentage short makereadies of the total number of makereadies (on respondents' folding equipment) between users and nonusers of scheduling software.

A larger group of the *users* (47.6%) have a short makeready percentage on the folding equipment that is 50% or greater, compared to the *nonusers* (27.3%). The mean percentage of short makereadies for the *users* is 40% and for the *nonusers* it is 37%.

<u>Summary</u>. The responding *users* of computer-assisted scheduling in the study have a higher percentage of short makereadies of the total number of makereadies compared to the respondents who do *not use* scheduling software. The difference between the *users* and *nonusers* is larger for the printing presses than the folding equipment.

Summary of Research Question 2

The difference in performance between users and nonusers of scheduling software was determined by analyzing two indicators: the distribution of responses and the mean value.

Difference in Distribution. The *nonusers'* distribution curves are more often evenly distributed along the x-axis. This indicates that the *nonuser* group has diverse performance within the group. The curves illustrating the *users'* responses are more often bell-shaped, meaning that the group is more homogeneous in terms of the investigated performance parameters.

The difference in distribution was also seen in the number of *users* and *nonusers* that performed at a very low versus very high level. The frequency of production meetings is excluded from this comparison because the efficiency of the meetings is more relevant than the frequency, and the efficiency of production meetings was not studied in this research. It was found that the percentage of *nonusers* performing at a very low level was higher for 7 of the 12 investigated parameters (original result) compared to the *users*. When adjusted for the outliers, 8 of the 12 investigated parameters had a higher percentage of *nonusers* performing at a very low level. For 5 of the 12 parameters, the percentage of *nonusers* performing at a very high level was higher than for the *users* (original result and result adjusted for outliers). A table showing the differences is presented in Appendix E.

Difference in Mean Value. The respondents in the study who *use* scheduling software perform better than *nonusers* in the following areas, according to the calculated means:

– Utilization rate on prepress equipment
– Utilization rate on printing presses
– Utilization rate on postpress equipment
– Waiting time: between paper arriving at plant from a supplier and beginning of press loading
– Percentage of short makereadies on printing presses
– Percentage of short makereadies on folders
– On-time deliveries (when adjusted for outliers)

The respondents in the study that do *not use* scheduling software perform better than *users* in the following areas, according to the calculated mean:

– Waiting time: between completed preflighting and beginning of platemaking
– Waiting time: between completed platemaking and beginning of plate mounting
– Waiting time: between completed printing and beginning of the first postpress operation
– Throughput time (original result, no adjustment for outliers)
– On-time deliveries (original result, no adjustment for outliers)

Users and *nonusers* of scheduling software perform at an equal level, according to the means, in the following parameters:

– Waiting time: Between completed product and beginning of transportation for delivery

– Throughput time (when adjusted for outliers).

The mean values for each of the investigated parameters and for *users* compared to *nonusers* are summarized in Table 14.

Table 14. Summary of the differences in mean values for users of scheduling software compared to nonusers in the investigated performance areas.

	Users	**Nonusers**
Equipment Utilization Rate: Prepress	67%	66%
Equipment Utilization Rate: Press	74%	68%
Equipment Utilization Rate: Postpress	77%	72%
Throughput Time	9 days	7 days
Throughput Time (Adjusted for Outliers)	7 days	7 days
Waiting Time: Between Completed Preflighting and Beginning of Platemaking	30 h	27 h
Waiting Time: Between Completed Platemaking and Beginning of Plate Mounting	15 h	10 h
Waiting Time: Between Completed Printing and Beginning of the First Postpress Operation	21 h	12 h
Waiting Time: Between Completed Product and Beginning of Transportation for Delivery	14 h	14 h
Waiting Time: Between Paper Arriving at Plant and Beginning of Press Loading	15 h	39 h
Rate Late Deliveries	5.2%	4.1%
Rate Late Deliveries (Adjusted for Outliers)	3.4%	3.6%
Percentage of Short Makereadies: Printing Presses	46%	41%
Percentage of Short Makereadies: Folders	40%	37%
Frequency of Production Meeting	More often	Less often

Discussion of Research Question 2

The *users* have a higher utilization rate than *nonusers* of scheduling software, while the *nonusers*, in most cases, have a shorter waiting time between operations. The scheduling software is used to schedule the printing presses by all of the respondents (100%) in the survey. A possible reason for the *users'* high utilization rate and long waiting time between operations might be that the *users* are too focused on scheduling the presses and forget to create a beneficial flow along the entire production chain. Another possible reason for the *users'* high utilization rates and long waiting times between operations could be weak scheduling software that is incapable of managing the entire printing process in an efficient way. This theory is supported by 25% of the *users*, who claimed that their scheduling software is inflexible.

The time a job spends between the completion of printing and beginning of the first postpress operation was very different between the *users* and the *nonusers.* The type of printing method, ink, and substrate used impact the time a job must wait before further processing to avoid quality issues such as set off, rub off, and cracked ink. Another reason for long waiting time could occur if the postpress operations are outsourced.

The only exception when the *users'* waiting time was shorter than that of the *nonusers* is for the paper – between its arrival from a supplier and the beginning of press loading. This indicates that the *users* manage their inventory well. Reduced inventory and JIT are significant sources of cost savings. In the survey, 43.3% of the *users* claimed to use their scheduling software for managing inventory.

The time from receiving an order to the finished product leaving the plant is dependent on the size of the jobs. Some of the responding companies might focus on longer runs than others and therefore have a longer throughput time.

The percentage of short makereadies was higher (better) on the printing presses compared to the folders for both *users* and *nonusers*. It is natural that the presses are scheduled first and the rest of the equipment must follow accordingly because presses are usually more expensive to own and to operate. Moreover, complete makereadies on presses might be more cumbersome and time-consuming than on other equipment.

Chapter 7

Conclusion and Discussion

Chapter 7 is divided into three sections: (a) conclusions based on the research results, (b) discussion of scheduling software, and (c) an agenda for further research.

Conclusion

The majority of the respondents in this study who own scheduling software but do not use it have no future plans to begin using it. The nonusers' opinion about computer-assisted scheduling does not match the users' experience with their software. It was not investigated whether the nonusers and users referred to similar software or if the reason for the different opinions is that nonusers own insufficient software while the users own software more appropriate for their business.

Nonusers believe that manual scheduling gives better control, whereas users have achieved better control with the scheduling software. Nonusers who have owned an MIS for 5 years or fewer are more negative toward using scheduling software.

There is a difference in performance between users of scheduling software and nonusers. Users utilize the equipment better and have a shorter cycle time from paper arriving at plant from a supplier to its being loaded in the press. Nonusers have shorter waiting time for a job between the operations, faster throughput time, and fewer late deliveries. The waiting time between operations is closely connected to the throughput time. The time a job spends between completion of the product and beginning of transportation for delivery is equal for both groups. The same is true for the throughput time when outliers are eliminated.

The users have a more similar performance level within their group, while some of the nonusers perform at very low levels and some at high levels. More nonusers than users have a very low performance level, and more users than nonusers have a very high performance level.

The inconsistency of performance levels in the nonusers group might be because some of the respondents have developed high efficiency through a focused quality strategy.

Discussion

The opportunity for scheduling software to enhance a lean manufacturing effort is discussed in this section, as well as the lessons learned.

Scheduling Software as an Enhancer for Lean Manufacturing

Common sense seems to be an effective guide in implementing lean manufacturing in an attempt to achieve efficiency and productivity. The founding philosophy of lean manufacturing is that any company or organization can practice it regardless of equipment or financial situation. No investment, aside from time, is needed. However, technology already in the house should be utilized, especially if it can enhance a lean manufacturing initiative. The responding users of scheduling software emphasize benefits such as an improved decision making process and a more organized workflow.

The disadvantages of using scheduling software are the high learning curve and the required frequent updating and feeding of input data. Providers of scheduling software need to make the software more user-friendly to facilitate implementation and usage. However, in many cases the “gray hair issue” (as Ray Prince, Senior Technical consultant at PIA/GATF expresses the high average age in the printing industry) is a possible reason for the high resistance among nonusers of scheduling software to start using it. Changes and new technology might seem scary, especially to the generation that constitutes the majority of the executives in printing companies today. With a generation shift may also come the willingness to adapt new technology.

Scheduling software is a possible enhancer for success in lean manufacturing for companies already owning a scheduling module.

Lessons Learned

Despite carefully formulated survey questions and pilot tests, there were a few issues that were revealed after the survey was conducted. In Question 16, “What is your company location’s average time from receiving an order to the finished product leaving the plant?” it is not clear whether the wording “receiving an order” means receiving the initial phone call from a customer who is interested in a print job or if it means receiving the print files from a customer. The latter is what was intended in the question.

Many of the questions were multiple-choice questions with answer intervals such as 6-10% and 11-15%. In four questions, these intervals were not clearly delineated.

Agenda for Further Research

One of the objectives of this research was to find whether there was a difference in performance between users and nonusers of scheduling software regarding a set of parameters. Further studies can be done in each of the parameters investigated to find out if the differences found result from the usage of computer-assisted scheduling or if other factors may impact the results. In this research, the frequency of production meetings was compared between the users and nonusers of scheduling software. Further studies could focus on the efficiency of production meetings and their importance.

Reducing the waiting time for a print job between the involved operations and functions can reduce throughput time. In this research, it was found that the waiting time in many cases seemed unnecessarily long. A study focusing on the methods for reducing waiting time and the impact of them would probably be of interest for the industry.

Another suggestion for further research would be to look further into what factors would motivate the nonusers who already own the scheduling software to begin using it. What characteristic does the scheduling software of today lack?

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Appendix A

Appendix A

Why Not a Quantitative Study?

For this research project, the estimates for an appropriate number of responses for a valid quantitative study with random sampling turned out to be between 100 and 400 according to calculations presented below. The expected low response rate and prerequisite of ownership of an MIS are large barriers to conducting a financially feasible quantitative study.

The following is the formula for determining the sample size with a population size of 17,400 establishments:

$$n = \frac{(z_{\alpha/2})^2 \, p^* \, (1 - p^*)}{E^2}$$

Where,

n = sample size
$z_{\alpha/2}$ = the z value providing an area of $\alpha/2$ in the upper tail of the standard normal distribution, determined by the confidence level
p* = planning value for the sample proportion (p)
E = margin of error

A confidence level of 95% will be used. It is a commonly used confidence level. According to the table for standard normal distribution, a confidence level of 95% means that 95% of the values of any normally distributed random variable are within ±1.96 ($z_{\alpha/2}$) standard deviations of the mean (Anderson, Sweeney, & Williams, 2005).

Confidence level 95% = .95 confidence coefficient = $(1 - \alpha)$
=> $\alpha = .05$ => $(\alpha/2) = .025$
$z_{\alpha/2} = 1.960$ (according to the table for standard normal distribution)

The planning value (p^*) is used when the sample proportion (p) is unknown. There are four different ways to chose the value of p^*: by using a previous sample proportion, by conducting a pilot study and using the p from the findings, or by using a "best guess" or judgment. If none of the above alternatives apply, the fourth alternative is to use a planning value of $p^* = .50$ (Anderson, Sweeney, & Williams, 2005). The sample proportion is the estimated proportion of the nonusers of scheduling software that are expected to refuse usage because of a specific reason, estimated by the researcher (Pray, 2007). In this analysis, the fourth alternative, $p^* = .5$, will be used for the estimate of appropriate sample size.

The margin of error (E) determines how close to the truth the estimate will be (Pray, 2007). According to Anderson, Sweeney, and Williams (2005): "The margin of error for estimating a population proportion is almost always .10 or less" (p. 320). A smaller margin of error requires a larger sample size. Two margins of error will be determined to find an interval in which the number of responses should fall.

a) $E = .10 \Rightarrow \quad n = \dfrac{(1.96)^2 \, .5 \, (1 - .5)}{.10^2} \quad \Rightarrow n = 96.04 \approx 96$

b) $E = .05 \Rightarrow \quad n = \dfrac{(1.96)^2 \, .5 \, (1 - .5)}{.05^2} \quad \Rightarrow n = 384.16 \approx 385$

If the response rate is 5% and 50% of the commercial printers in the U.S. own an MIS (Cost & Daly, 2003), a sample size of at least 8000 would be necessary to receive 200 responses.

Appendix B

Appendix B

Email Survey

Default Section

Does your company location use a print-specific management information system (MIS)/print management system?

- ○ Yes
- ○ No, not a print-specific MIS but a generic MIS, home-grown, or ERP system
- ○ No

For how long have you been using your MIS or ERP system?

- ○ < 6 months
- ○ 7-12 months
- ○ 1-2 years
- ○ 2-5 years
- ○ 6-10 years
- ○ > 10 years

Does your company location own a scheduling module/scheduling software*?

- ○ Yes, we own one but do not use it
- ○ Yes, we own one and use it
- ○ No, we do not own one

* Please do NOT include electronic spreadsheets such as EXCEL or similar spreadsheet software.

Yes, we own a scheduling module/software but do not use it.

Is your scheduling module/software . . . ?

- ○ Built into a print-specific management information systems (MIS)
- ○ Built into a generic MIS, home-grown MIS, or ERP system
- ○ Home-grown
- ○ Stand-alone software from a vendor

Comment:

Please rate how strongly you agree or disagree with the following statements.
(4= Strongly Agree, 1= Strongly Disagree)

We do not use our scheduling software because it is . . .

	Strongly Agree (4)	Somewhat Agree (3)	Somewhat Disagree (2)	Strongly Disagree (1)
Slow	○	○	○	○
Inflexible	○	○	○	○
Difficult to learn	○	○	○	○
Difficult to use	○	○	○	○
Difficult to integrate with our workflow	○	○	○	○
Difficult to integrate with our MIS/ERP	○	○	○	○
Too costly to implement	○	○	○	○
Would not improve our profitability	○	○	○	○
Requires too much input data	○	○	○	○
Requires an organizational change that we are not willing to do right now	○	○	○	○
Not necessary for our business	○	○	○	○
Cannot handle our unique press characteristics	○	○	○	○
Achieve better control with manual scheduling	○	○	○	○
Do not have a shop floor data collection system	○	○	○	○
Are missing necessary supportive technology	○	○	○	○
Current estimating procedures do not support the scheduling software	○	○	○	○

Other (please specify)

Do you have plans to start using your scheduling software within . . . ?

- ○ . . . 6 months
- ○ . . . 1 year
- ○ . . . 5 years
- ○ No, no plans

What is your motivation to start using your scheduling software?

Yes, we own a scheduling module/software and use it.

For how long have you been using your scheduling module/software?

Is your scheduling module/software . . . ?

- ○ Built into a print-specific management information systems (MIS)
- ○ Built into a generic MIS, home-grown MIS, or ERP system
- ○ Home-grown
- ○ Stand-alone software from a vendor

What operations in your company location are planned and scheduled through the scheduling software?
Please check all that apply.

- ☐ Inventory (material) management
- ☐ Preflighting
- ☐ Prepress
- ☐ Proofing
- ☐ Platemaking
- ☐ Error fixing/remakes
- ☐ Press
- ☐ Bindery
- ☐ Packaging
- ☐ Distribution
- ☐ Other (Please specify)

Please rate how strongly you agree or disagree with the following statements.
(4= Strongly Agree, 1= Strongly Disagree)

We have gained the following benefits through our scheduling module/software?

	Strongly Agree (4)	Somewhat Agree (3)	Somewhat Disagree (2)	Strongly Disagree (1)
Reduced idle time on platemaking equipment	○	○	○	○
Reduced idle time on press	○	○	○	○
Reduced idle time on bindery equipment	○	○	○	○
Reduced paper waste	○	○	○	○
Reduced need for human judgment	○	○	○	○
Reduced need for production meetings	○	○	○	○
Reduced cost	○	○	○	○
Reduced stress level for employees	○	○	○	○
Reduced overtime	○	○	○	○
Increased throughput time	○	○	○	○
Increased rate of on-time deliveries	○	○	○	○
Increased profit	○	○	○	○
Increased prepress productivity	○	○	○	○
Increased press productivity	○	○	○	○
Increased bindery productivity	○	○	○	○
Improved decision making process	○	○	○	○
Improved control of production	○	○	○	○
More organized workflow	○	○	○	○

Other (please specify)

What disadvantages have you experienced with your scheduling software? Please check all that apply.

- ☐ Slow
- ☐ Inflexible
- ☐ High learning curve
- ☐ Long implementation process
- ☐ Difficult implementation process
- ☐ Difficult to integrate with our workflow
- ☐ Difficult to integrate with our MIS/ERP
- ☐ Difficult to get a quick overview of the entire plant schedule
- ☐ Requires too much updating
- ☐ Requires too much input data
- ☐ Expensive to implement
- ☐ Input errors common
- ☐ Increased stress level for employees
- ☐ Has not improved our profitability
- ☐ Needs too much complementary human judgment
- ☐ Need additional supportive technology
- ☐ Current estimating procedures do not support the scheduling software
- ☐ Other (please specify)

No, we do not own a scheduling module/software.

Please rate how strongly you agree or disagree with the following statements.
(4= Strongly Agree, 1= Strongly Disagree)

We have not purchased scheduling software because it is . . . ?

	Strongly Agree (4)	Somewhat Agree (3)	Somewhat Disagree (2)	Strongly Disagree (1)
Too expensive	O	O	O	O
Too slow	O	O	O	O
Inflexible	O	O	O	O
Difficult to learn	O	O	O	O
Difficult to use	O	O	O	O
Difficult to implement	O	O	O	O
Difficult to integrate with our workflow	O	O	O	O
Difficult to integrate with our MIS/ERP	O	O	O	O
Requires too much input data	O	O	O	O
Not necessary for our business	O	O	O	O
Have not found the right solution	O	O	O	O
Have not found a vendor we would like to work with	O	O	O	O
Would not improve our profitability	O	O	O	O
Can control the scheduling function better without it	O	O	O	O
Cannot handle our unique press characteristics	O	O	O	O
Do not have a shop floor data collection system	O	O	O	O
Are missing necessary supportive technology	O	O	O	O
Requires an organizational change that we are not willing to do right now	O	O	O	O
Current estimating procedures do not support the scheduling software	O	O	O	O

Other (please specify)

Do you have plans to purchase scheduling software within . . . ?

- O . . . 6 months
- O . . . 1 year
- O . . . 5 years
- O No, no plans

What is your motivation to purchase scheduling software?

Part 2

What is your company location's average time from receiving an order to when the finished product leaves the plant?

- O 1 day or less
- O 2-4 days
- O 5-8 days
- O 9-14 days
- O 15-30 days
- O More than a month

Comments:

What percentages of the jobs are delivered after the delivery date on the order specification?

- O < 2%
- O 3-5%
- O 6-10%
- O 11-15%
- O 16-20%
- O 21-30%
- O >31%

Comments:

On average, what is the utilization rate* of the equipment in the following areas? (*The percentage of time during a shift that the equipment is operating)

	< 40%	41-50%	51-60%	61-70%	71- 80%	81-90%	> 91%
Preflighting	O	O	O	O	O	O	O
Prepress	O	O	O	O	O	O	O
Proofing equipment	O	O	O	O	O	O	O
Platemaking equipment	O	O	O	O	O	O	O
Web presses	O	O	O	O	O	O	O
Sheetfed presses	O	O	O	O	O	O	O
Digital presses	O	O	O	O	O	O	O
Cutting equipment	O	O	O	O	O	O	O
Folding equipment	O	O	O	O	O	O	O
Binding equipment	O	O	O	O	O	O	O

How often do you have production meetings?

- O More than once a day
- O Once a day
- O 2-3 times a week
- O Once a week
- O Never

On average, how many complete makereadies* and short makereadies do you have every day, considering all your printing presses/folders?**

Printing presses

Complete makeready*

Short makeready**

Folding equipment

Complete makeready*

Short makeready**

*Complete makeready = Major changes of machine settings, such as for different inks, different paper (size/stock), and/or different folds.
**Short makeready = Using same inks and machine configurations as the previous job.

What is the average time that a job spends between each of the following operations/functions?

	< 1 h	2-4 h	5-7 h	8-10 h	11-24 h	2 days	3 days	> 3 days
Between completed preflighting and beginning of platemaking	○	○	○	○	○	○	○	○
Between completed platemaking and beginning of plate mounting	○	○	○	○	○	○	○	○
Between paper arriving at plant (from a supplier) and beginning of press loading	○	○	○	○	○	○	○	○
Between completed printing and beginning of the first postpress operation	○	○	○	○	○	○	○	○
Between completed product and beginning of transportation for delivery	○	○	○	○	○	○	○	○

Please, fill in the name of your company. This will ensure that you will not receive additional requests to complete the survey. All responses will be kept strictly confidential.

Would you be willing to be contacted for a follow-up interview?

○ Yes ○ No

If yes, please give your name and contact information in the box:

Appendix C

Appendix C

Cover Letter

Dear Mr./Ms. Lastname,

My name is Sandra Yveborg. I am a graduate student at the School of Print Media, Rochester Institute of Technology (RIT), Rochester, NY. Currently, I am working on my master's thesis in the field of efficiency and productivity gains through the scheduling function for American printers. The study is conducted in close cooperation with my thesis advisor, professor Barbara Birkett.

As part of the study I am conducting a survey among U.S. printers. Included in this email is a link to a short online survey, which takes less than 10 minutes to complete. Would you please complete the survey?

All responses will be kept strictly confidential, and only summary results will appear in my thesis. As a respondent, you will receive the summary results and analysis.

Survey link:
http://www.surveymonkey.com/linkto/thefantastic/survey

Your input will be very much appreciated.

Thank you,
Sandra Yveborg
585-208-8026

School of Print Media
Rochester Institute of Technology

Appendix D

Appendix D

Modified Cover Letter as Reminder to Answer Survey

Dear Mr./Ms. Lastname,

I understand that your time is limited, but your input would be highly valued and appreciated in my work on a master's thesis. This is a follow-up request asking you to complete a short online survey about the scheduling function in your plant location. The survey should take 8 to 12 minutes to complete. The link to the survey is included in this email.

My name is Sandra Yveborg. I am a graduate student at the School of Print Media, Rochester Institute of Technology (RIT), Rochester, NY. Currently, I am working on my master's thesis in the field of efficiency and productivity gains through the scheduling function for American printers. The study is conducted in close cooperation with my thesis advisor, professor Barbara Birkett.

All responses will be kept strictly confidential, and only summary results will appear in my thesis. As a respondent, you will receive the summary results and analysis.

Survey link:
http://www.surveymonkey.com/linkto/thefantastic/survey

Your input will be very much appreciated.

Thank you,
Sandra Yveborg
585-208-8026

School of Print Media
Rochester Institute of Technology

Appendix E

Appendix E

Percentage Very Low and Very High Performance Level

Dark green highlighted fields indicate the user or nonuser group that has the highest percentage of very high performance. Dark pink highlighted fields indicate the user or nonuser group that has the highest percentage of very low performance.

Original Result	Very High Performance Level		Very Low Performance Level	
	Users	Nonusers	Users	Nonusers
	> 80%		≤ 50%	
Utilization Rate: Prepress	23.0%	38.8%	16.0%	22.3%
Utilization Rate: Press	42.9%	35.4%	8.2%	20.8%
Utilization Rate: Postpress	64.0%	39.2%	6.7%	10.8%
	≤ 4 days		> 8 days	
Throughput	21.4%	29.6%	17.9%	14.8%
	< 2%		> 5%	
Ontime delivery	50.0%	55.6%	21.4%	25.9%
	< 1 hours		> 10 hours	
Between preflighting and platemaking	18.5%	4.0%	55.6%	44.0%
Between platemaking and plate mounting	11.1%	16.7%	29.6%	33.3%
	≤ 4 days		≥ 2 days	
Between paper arrival and press loading	29.6%	4.0%	11.1%	48.0%
	≤ 10 hours		≥ 2 days	
Between printed product and postpress	39.3%	50.0%	17.9%	0.0%
	≤ 4 days		> 10 hours	
Between completed product and delivery	21.4%	19.2%	50.0%	38.5%
	> 50%		< 25%	
Percentage Short Makeready: Presses	40.0%	29.2%	20.0%	20.8%
Percentage Short Makeready: Folders	33.3%	18.2%	28.6%	22.7%

Result Adjusted for Outliers	Very High Performance Level		Very Low Performance Level	
	Users	Nonusers	Users	Nonusers
	> 80%		≤ 50%	
Utilization Rate: Prepress	23.0%	38.8%	16.0%	22.3%
Utilization Rate: Press	42.9%	35.4%	8.2%	20.8%
Utilization Rate: Postpress	64.0%	39.2%	6.7%	10.8%
	≤ 4 days		> 8 days	
Throughput	25.9%	29.6%	11.1%	16.7%
	< 2%		> 5%	
Ontime delivery	53.8%	57.7%	15.4%	23.1%
	< 1 hours		> 10 hours	
Between preflighting and platemaking	18.5%	4.0%	55.6%	44.0%
Between platemaking and plate mounting	11.1%	16.7%	29.6%	33.3%
	≤ 4 days		≥ 2 days	
Between paper arrival and press loading	29.6%	4.0%	11.1%	48.0%
	≤ 10 hours		≥ 2 days	
Between printed product and postpress	39.3%	50.0%	17.9%	0.0%
	≤ 4 days		> 10 hours	
Between completed product and delivery	21.4%	19.2%	50.0%	38.5%
	> 50%		< 25%	
Percentage Short Makeready: Presses	40.0%	29.2%	20.0%	20.8%
Percentage Short Makeready: Folders	33.3%	18.2%	28.6%	22.7%